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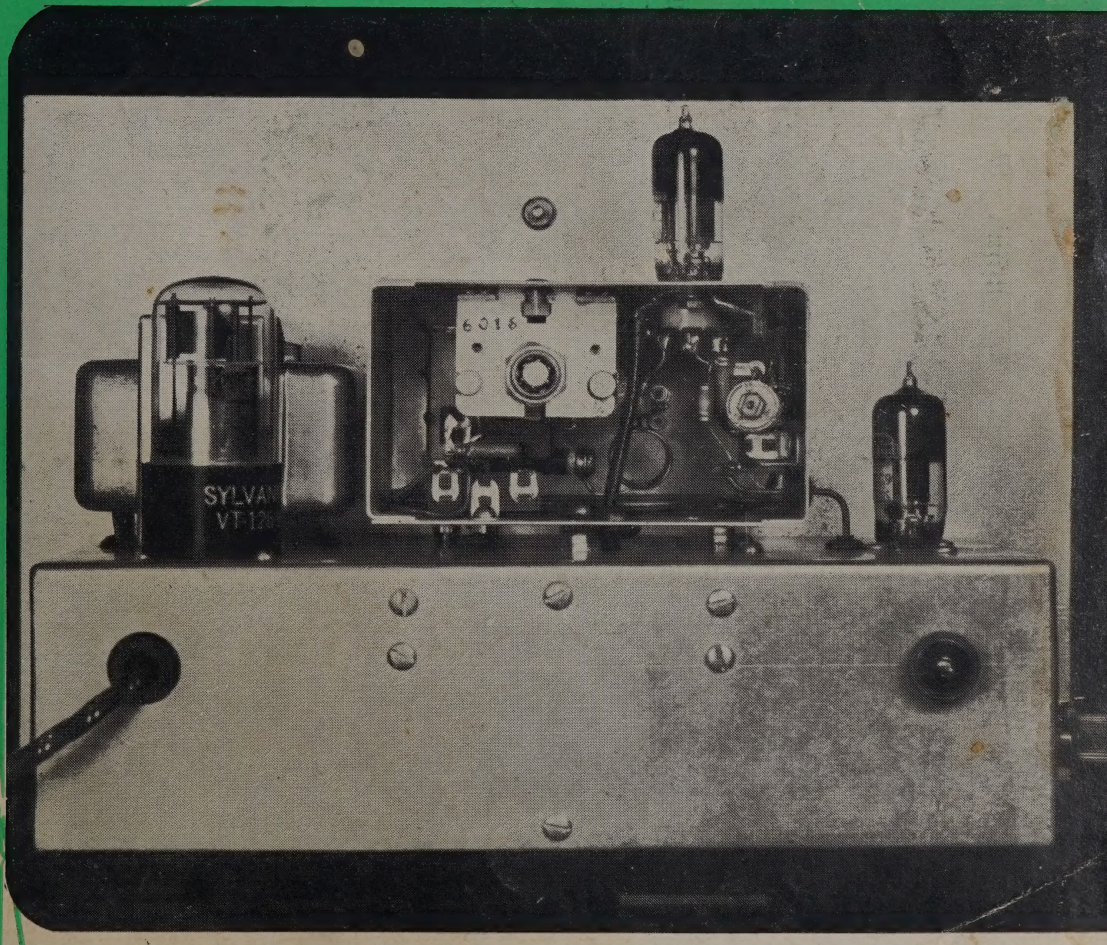

AUGUST 1, 1949

VOL. 4, NO. 6

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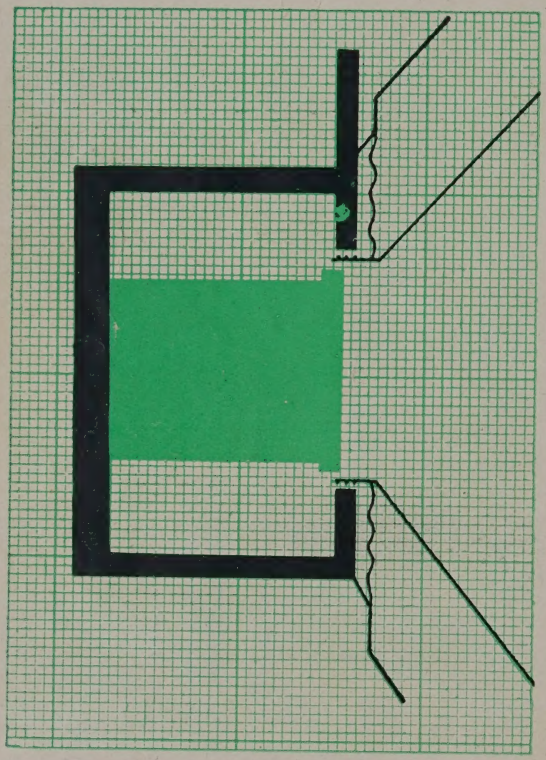

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RADIO and ELECTRONICS

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OUR COVER

Our cover this month shows a view of the high-performance 2-metre converter (I.F. 14 mc/sec.), whose construction is described in this issue. The circuit of this converter was described in "Radio and Electronics" in June, 1949.

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GUY E. MILNE
ELECTRONIC TECHNICIAN

A Broadcast Field-Strength Survey

In our June issue of this year, we commented editorially on the desirability of a comprehensive field-strength survey of our broadcast stations. When that editorial was written, we had not conferred with any of the interested parties, and what we wrote was intended simply as an idea which we ourselves thought worth while, and which could be expected to commend itself,in particular, to the manufacturers. A suggestion which we expected to cause some comment (not necessarily favourable) was that, if necessary, the radio manufacturers, as a body, should be prepared, at least as a last resort, to foot the bill themselves.

We realize, of course, that making a survey would be a long and rather costly business, especially if it is to be at all complete in scope, and that there are any amount of arguments, from the manufacturers' point of view, against their carrying it out themselves. An obvious alternative, if the Broadcasting Service is not going to act on its own initiative, is that the project should be handled by the Radio Research Committee, in conjunction with the Department of Scientific and Industrial Research. Since the editorial referred to was printed, we have been reliably informed that a survey is to be taken by the D.S.I.R., at the instigation of the Radio Research Committee. The work is expected to take three years to complete, after which the findings will be published and the results thus made available to all interested parties.

This is good news indeed, both for listeners and for manufacturers. Anything which benefits the listening public must, to our way of thinking, benefit the latter also, and we would like to express our appreciation of the foresight shown by those who have been instrumental in putting the project into operation. Although the complete survey will take such a long time, this does not mean that useful results will not be obtained in a much shorter time, for there seems no good reason why the results for the various important areas should not be forthcoming as these areas are covered, in much the same way as ordinary maps are made piecemeal as the survey work is completed.

The manufacturers would perhaps be well advised to request the responsible authorities to commence the survey in the areas which are most in need of improved coverage, and, by the same token, the D.S.I.R. will, it is hoped, arrange the programme, in consultation with the N.Z.B.S. and the Radio Manufacturers' Association, so that the most important results are forthcoming at the earliest possible date.

Quality Reproduction in High-Priced Domestic Sets

We had occasion, the other day, to visit the premises of a well-known retailer of radio sets and to hear the performance of the largest and most expensive model of a reputable and old-established manufacturer, who, for obvious reasons, shall be nameless.

To say that we were astonished would be to put the case too mildly, but the unfortunate thing is that our astonishment was not due to the excellence of the receiver heard, but rather the reverse. The model concerned was a radio-gramophone combination. Its price was in excess of £100, and yet the quality of reproduction was shockingly poor. We have heard many sets—and much smaller, less pretentious ones at that—which gave infinitely better reproduction at a fraction of the price.

It appears to us that there is something very wrong in conditions which allow a thing like this to happen. That section of the public which is prepared to spend more than the minimum price of a reasonably good set is entitled to get something more for his money than a beautiful piece of cabinetwork containing a reproducing system that is poor, judged by any standard. He is entitled to expect not only a handsome piece of furniture, but also a performance which matches the appearance. The fact that a large number of buyers are not capable of discriminating between good and bad reproduced quality has nothing whatever to do with the argument. To turn out and sell a set such as the one we heard the other day can only be described as very poor business. At the lowest level of criticism—that which regards only the makers' own interest—it is bad practice, for sooner or later he will be found out, and the fact will be reflected in his sales figures.

While manufacturing costs are high, so, in the case of the alleged high-quality receiver, is the price that the customer pays, so that there is no possible excuse for presenting him with a set whose output at only medium power levels is palpably distorted. Ethically speaking, it is indefensible. Nor can it be pleaded with any sort of reasonableness that the buyer is not compelled to buy. Perhaps not, but he is being grossly misled, if only by implication—namely, that if the price is high and the appearance good, then the whole product must be better than similar but lower-priced equipment.

There used to be a thing called pride of workmanship, which fortunately still exists in some quarters. It certainly can not in the case which we cite here. Unfortunately such individual lapses react on the whole industry. There is one way in which the industry could protect itself, though, and this is by laying down performance standards for sets in prescribed price classes. It could not be made obligatory for any manufacturer to conform to such standards, but their existence would be an incentive to all manufacturers to reach and exceed them, with obvious beenfits to the consumer and themselves.

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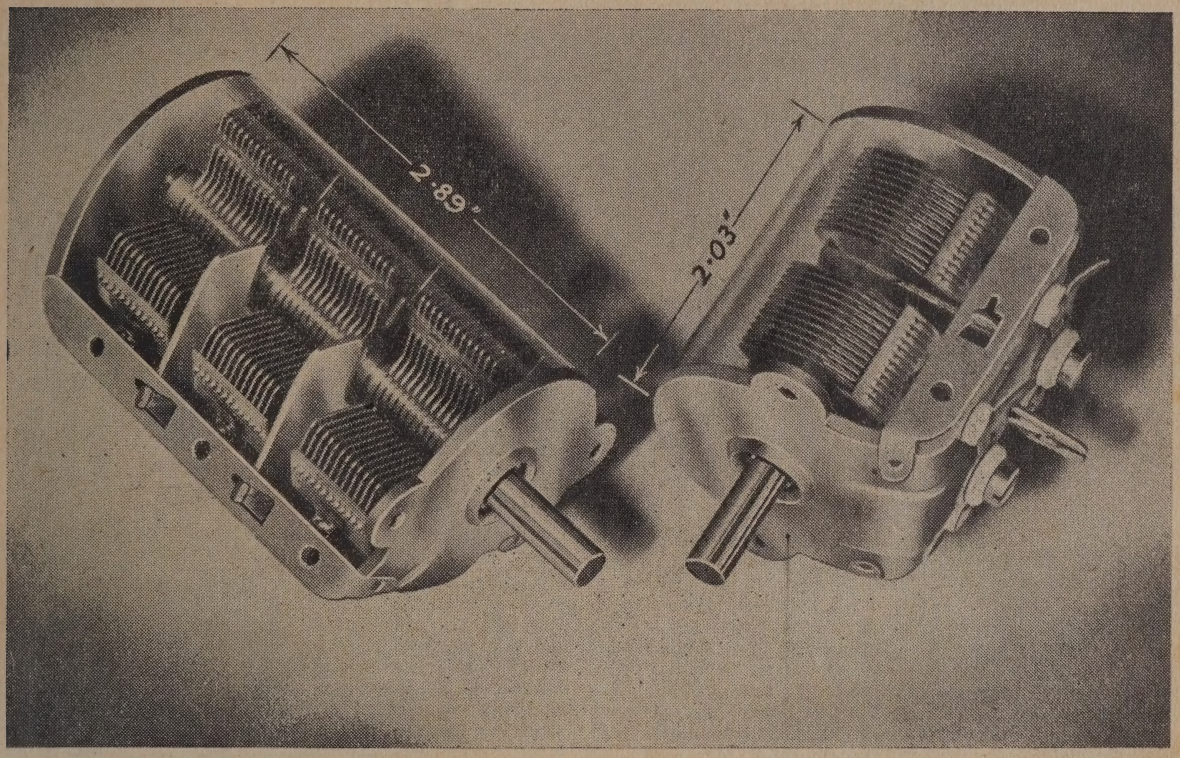

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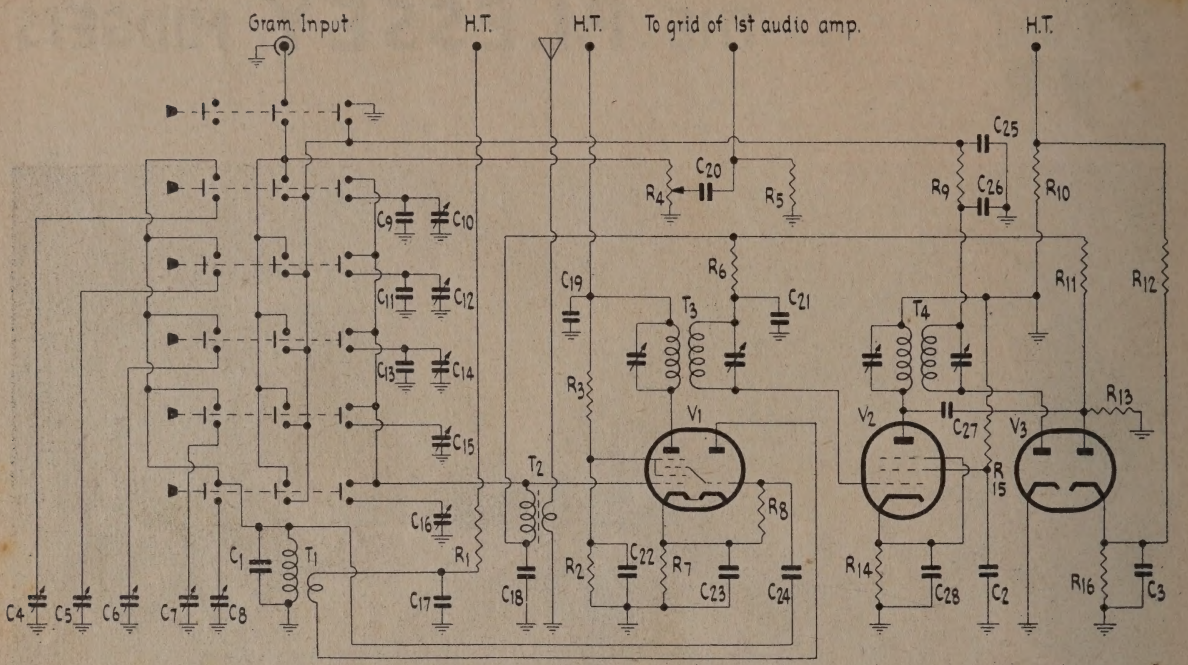
A Push-Button Tuner for High-Quality Reception

Two issues ago we published the circuit for a high-quality audio amplifier, and promised readers a circuit for a push-button tuner which would be complementary to it. This tuner is described here, and will give a quality that is present in our Broadcasting Service's transmissions, but which is hardly ever taken full advantage of, even by high-priced receivers.



INTRODUCTION

Although push-button tuning systems were quite the rage before the war, they have ceased to be a feature of our own locally-built sets, and are seldom seen in foreign designs either. There are a number of reasons for this, chief among which is the technical difficulty of keeping a push-button receiver properly tuned over long periods of time. There are remedies, such as automatic frequency control, but they are expensive, and the push-button appears to be shunned by commercial designers. However, in the present application, owing to the intentionally small selectivity of the tuner, it is possible to tolerate much more tuning drift than when the receiver is very selective, and we consider that the design given here is quite stable enough to hold its tuning over very long periods of time.

SCHEME OF THE TUNER

Although we do not claim that this tuner is the ideal solution to the problem of wide-range reception of local stations, we know that, in conjunction with a good amplifier, it can give very much better results than can any conventional tuner, and so we have no hesitation in recommending it to intending builders. Increased bandwidth is achieved by raising the intermediate frequency of an otherwise conventional superhet. circuit to 2000 kc/sec. We have previously described a similar tuner, which differed in some important details from this one. The former used a single condenser, tuning the oscillator circuit only, as the tuning control; in order to avoid the difficulties of tracking the signal circuit with the unusual oscillator arrangement, the aerial circuit was not tuned at all. This scheme has one grave disadvantage—that of possible spurious responses, causing whistles and the like—which is absent in the present design. This time, since push-buttons are used, there is no question at all of tracking the signal and oscillator circuits, so that we have a tuned aerial circuit in the ordinary way, and the tuner is as free from "birdies," etc., as any conventional set.

The increase of bandwidth is the same thing as a reduction in selectivity, so that, although we gain a great deal by way of improved high-frequency response, we lost some of the normal set's ability to discriminate between closely-spaced stations. For that reason, the tuner can be described as "local stations only," although the sensitivity is great enough for a distant station to be included on one of the push-buttons, provided that there is no breakthrough on the part of one of the locals.

The tuner consists of an oscillator-mixer, a single I.F. stage, and a double-diode, which acts as detector and A.V.C. rectifier. Thus, apart from the unusual I.F., the circuit is quite conventional, and its unusual appearance is due solely to the difficulty of making a push-button tuner look like an ordinary gang-tuned one.

COMPONENT LIST

V1, ECH35 or 6K8.
V2, 6SK7.
V3, 6H6.
C1, C24, 100 $\mu\mu$f.
C2, C3, C17, C19, C20, C21, C22, C23, C28, 0.1 μf.
C4, C5, C6, C7, C8, C10, C12, C14, C15, C16, 120 $\mu\mu$f.
(Each of these is one-half of a dual I.F. trimmer.)
C9, C11, C13, see text.
C18, 0.05 μf.
C25, C26, C27, 50 $\mu\mu$f.
R1, R8, R9, 50k.
R2, 35k.
R3, 25k.
R4, 500k. pot.
R5, 500k.
R6, 100k.
R7,200.
R10, 2k.
R11, R13, 1 meg.
R12, 250k.
R14, 250k.
R14, 250.
R15, 60k.
R16, 10k.
T1, oscillator coil (see text).
T2, aerial coil.
T3, T4, 1600 kc/sec. I.F. transformers tuned to 2000 kc/sec.

CIRCUIT IN DETAIL

The valves used are: V1, ECH35; V2, 6SK7; V3, 6H6. As stated above, their circuits are normal in every respect, so that we will describe in detail only the push-button arrangements and the oscillator coil, which, of course, is non-standard as far as a broadcast set is concerned, although it is readily available commercially.

The push-button unit used in our original had six buttons, but the same type may be had in any number of buttons from four to eight. Each push-button actuates three simple on/off switches, which are shown diagrammatically in the circuit. The top button on the diagram acts as the radio/gram changeover switch, and when it is pressed, the pick-up is ready for use and the tuner is deadened. The centre vertical row of switches is used to connect the pick-up to the audio amplifier in the case of the top button, and the output of the tuner, in all the others, each of which is used for one station. The left-hand vertical row of switches brings in the appropriate pre-set tuning condenser (C4 to C8 inclusive) in the oscillator circuit, while the right-hand row connects the pre-set tuning condensers for the aerial circuit (C9 to C16 inclusive). The whole arrangement is very simple, and need cause no worries whatever.

On the "gram." push-button, only the centre switch is needed to connect the pick-up to the amplifier, so that the remaining two switches on this button are available for any other work we may have for them. The left-hand one is shown unused, but the right-hand one is used to short-circuit the output line from the diode detector when the "gram." button is pressed, thus effectively silencing the tuner and preventing any radio signals from being heard when they are not wanted.

It should be noted that the audio volume control, R4, is mounted at the tuner, which is in any case meant to be built on the same chassis as the amplifier, and that it acts as the diode load resistor in the "radio" positions. R9, C25, and C26 form the filter which prevents I.F. voltage from being fed to the audio amplifier along with the audio signals. The lead from R4 to the push-button unit must necessarily be several inches long and should be shielded. The shielding will cause no undue loss of high frequencies, since its capacity to chassis simply forms part of the filter condenser C25, and aids in the filtering of I.F. voltage from the audio. Since R4 is the detector load resistor, it carries the D.C. diode current, so that a blocking condenser is essential, and this is shown as C20 in the diagram.

OSCILLATOR COIL

The oscillator coil for this tuner has to cover the range 2550 to 3500 kc/sec. in order to cover the broadcast band. The coil used in the original was thus not a broadcast oscillator coil at all. However, it is a standard oscillator coil for the medium-wave range, and can be purchased quite readily from any retailer. C1 is a 100 $\mu\mu$f. mica condenser which is in parallel with the coil on all push-button positions, and so is connected right at the coil. The variables, C5 to C8 inclusive, are the pre-set tuning condensers.

TUNING CONDENSERS

For tuning five stations, ten pre-set condensers are needed, and the cheapest, as well as the most satisfactory way of getting these is to use dual I.F.

(Continued on page 46.)

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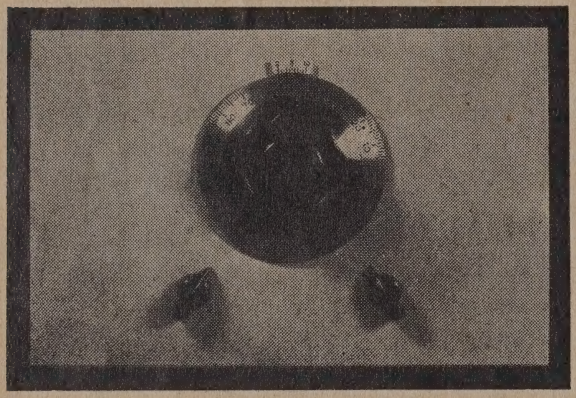
Building the *Radio and Electronics* 144 mc/sec. Converter

In our June issue we gave the circuit and a fairly complete description of a converter for the 2-metre amateur band. This embodied several advanced features, and is a really excellent performer, very suitable for those who want to take up serious work on this increasingly popular band. In order to further assist those who may not have done very much V.H.F. work, we are printing a description of the construction of this unit, complete with built-in power supply, on the chassis the drawings of which were given in the original article.

INTRODUCTION

Under this title "A Converter for the 144–148 mc/sec. Amateur Band," we published, two issues ago, the description of a circuit which was designed in our laboratory to fill the requirement for a stable, easily-handled 2-metre-band converter for fixed use. This unit has an I.F. of 14 mc/sec., making it suitable for use in front of any amateur communications receiver. It had many useful features which contributed to make it as easy to handle as any ordinary receiver. The 144 to 148 mc/sec. band was spread over approximately 135 deg. of a 180 deg. dial, and effects which make proper tuning difficult, such as oscillator pulling and drift, have been largely eliminated by the use of a simple oscillator-doubler system instead of the more usual straight oscillator. In addition, the building of this oscillator-doubler combination in a small metal box, with the valve mounted on the outside, makes a very useful contribution to the frequency stability. In fact, the stability of the whole converter (which does not use a regulated power supply) is so good that it was quite satisfactory to use with a double-conversion receiver with far better than average selectivity in the second I.F. channel.



Front view of the converter, showing the simplicity of its controls. The main dial tunes the oscillator, the left-hand knob the mixer grid, and the right-hand one is an on/off switch.

This is a real test of stability for any converter, oscillator system shows up by the signal drifting out of tune, thus necessitating frequency re-tuning of the converter to keep the signal "on the nose." Of course, if a highly selective set is to be used to follow the converter, it is essential for the received signal to have a like measure of frequency stability under modulation, and it is not suggested that this would be a good arrangement. It would be quite all right where the received signal was crystal-controlled, with very small drift and no frequency modulation, but for the average run of signals that is likely to be heard on 2 metres as yet, extreme selectivity would be more nuisance than it was worth. A superhet. is, in any event, an unsatisfactory receiver for a signal which suffers from frequency modulation, and with any reasonable degree of selectivity, the modulated oscillator type of transmitter will usually be impossible to copy.

We have already published data on suitable low and medium-power transmitters for the 2-metre band, and this converter is really intended as a companion for these. So, if you are building this converter and co-operating with other "hams" in getting going on the band, make sure that some of them at least are using transmitters that are not just modulated oscillators, or bad communication could easily be put down, quite wrongly, to poor receiver performance instead of to its true cause—transmitter instability.

MECHANICAL CONSIDERATIONS

This little homily has been given both to help readers and as an illustration of the importance of receiver stability in V.H.F. work. For, if transmitter stability is going to be one of the difficulties (as in some attempted contacts it certainly will be), a receiver which suffers from oscillator drift will only add to the trouble, since the apparent drift when a signal is received is the sum of transmitter and receiver drifts. To some extent these may counteract each other, but one should not rely on this happening.

It behoves us, therefore, to make our converter as good a mechanical and electrical job as possible, and this further article has been written to assist would-be builders in this respect.

BUILDING THE OSCILLATOR-DOUBLER SECTION

Naturally, the part of the converter that is most critical in the above respect is the local oscillator. In this case we have a 6J6, one-half of which is used as an oscillator and the other as a broad-band doubler. The oscillator has a frequency range of 65 to 67 mc/sec., which is doubled to 130 to 134 mc/sec. This is 14 mc/sec. lower than the signal band, and gives the correct injection frequencies for the mixer stage.

The oscillator-doubler stage is mounted in the small box, and the arrangement of parts inside the box can be seen in the photograph which appears on this month's front cover. An end view of the oscillator coil is obtained, but the doubler coil is hidden behind the terminal strip on the right. On this strip can be seen the Philips trimmer which tunes the doubler-plate coil. Next to this condenser can be seen the 10k. loading resistor across the doubler-tank circuit and the minute 15 $\mu\mu$f. coupling condenser which goes to the terminal strip, whence the lead goes through the box and through the chassis to the injection grid of the 6J6 mixer. There can also be seen a piece of earthing braid, covered in spaghetti, running from an earth lug on the valve

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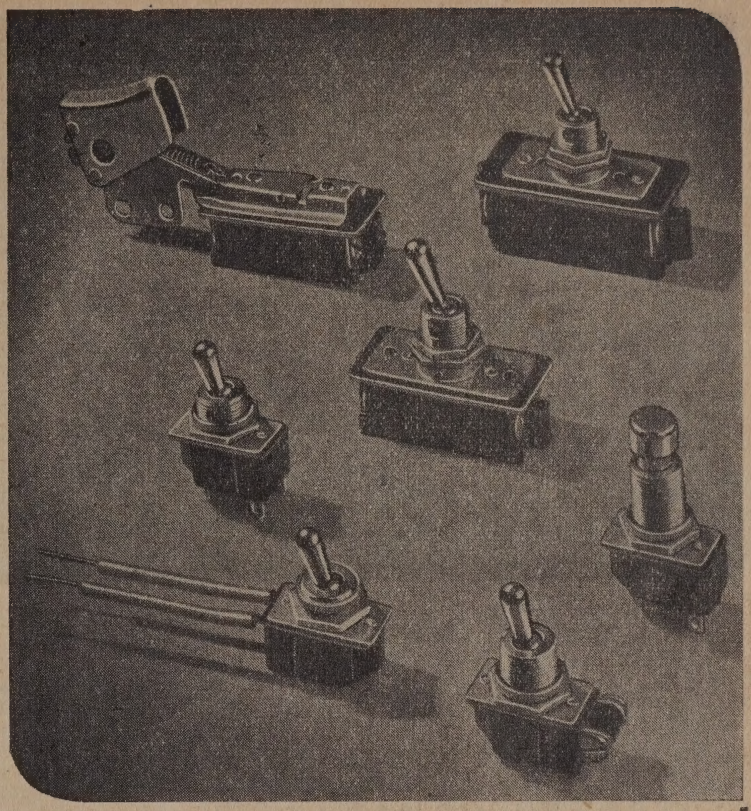

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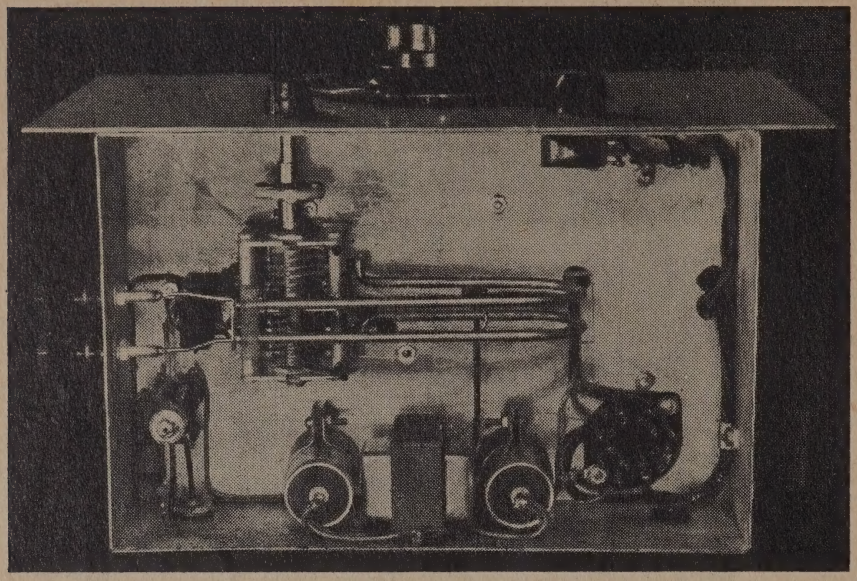
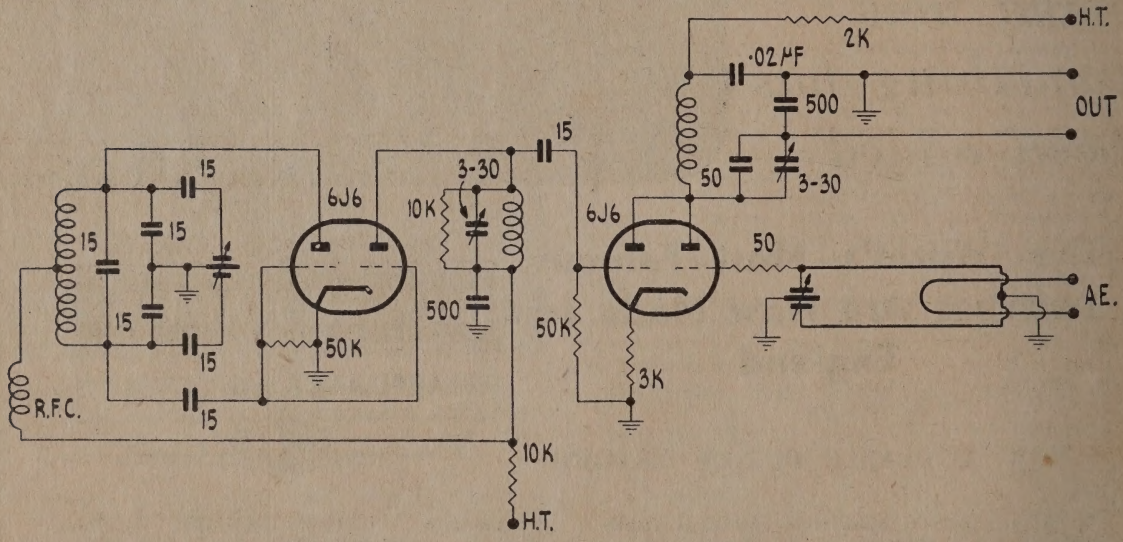


Underneath view of the converter. This gives a good close-up of the line-tuned mixer grid circuit. There is no support at the U-bend at the right, but only a perspex spacer. The hairpin loop from the aerial terminals on the left is under the top part of the line. The I.F. output circuit is just in front of the aerial terminals, with its Philips trimmer on top.



socket, vertically downwards through the box and the main chassis. This braid is grounded to the chassis at the single earthing point for the mixing circuit, and makes a one-point earth for the whole oscillator-doubler circuit, thereby preventing undesired oscillator coupling from taking place, and ensuring that the only oscillator coupling that exists to the mixer circuit is by way of the injection grid lead, as shown on the circuit. If undesired coupling exists, it can quite easily cancel or reinforce the desired coupling, in either case making improper mixer operation possible.

Although there appears to be a good deal in a small space within the oscillator compartment, it is possible to wire the circuit without having to construct the whole thing outside and then squeeze it into the box. Our own one was wired in the ordinary way with a soldering bit ¼ in. in diameter and two inches or so long, without undue difficulty.

The box is given a flexible mounting in a very simple manner. Three mounting holes are bored in the bottom of the box and small rubber grommets are inserted. Corresponding holes are bored in the chassis for the mounting bolts to go through. The latter are fixed through the grommets in the box with two nuts, which can be seen in the photograph, and further nuts are screwed on under the chassis. The bolts are by this means rigidly fixed to the chassis, but the small amount of play in the grommet prevents the box from being quite rigid. The amount of play provided can be adjusted by tightening or

(Continued on page 41.)

QUESTIONS AND ANSWERS

THE "R. & E." PANORAMIC ADAPTOR

W.T.S., Palmerston North, writes that he is experiencing a certain amount of difficulty with the panoramic adaptor published in our pages a few months ago. Summarized, his troubles seem to amount to (a) insufficient voltage output from the X and Y amplifiers, and (b) that he is attempting to get too great a frequency sweep from the FM oscillator in the adaptor. A third trouble is that of insufficient sensitivity.

W.T.S. states that he has tried an extra stage of amplification in the X axis, between the sweep generator and the amplifier, without success, and that various valves have been tried as the amplifier stage without success. Now this is quite as one would expect, when the cathode ray tube type that W.T.S. is using is taken into account. This is a 5BP1, and not a 3AP1, for which the circuit was originally designed. The difference in deflection sensitivity is very marked, and a 5 in. tube will need a good deal more available output voltage from the amplifiers if the whole face is to be used, both because of this and because the one tube is nearly twice the diameter of the other.

The deflection factor for a 5BP1 with 1500 volts on the final anode is 56 volts per inch for one pair of plates, and 64.5 volts per inch for the other, so that, on the assumption that the whole diameter of the tube is to be used, a peak-to-peak amplitude of 280 and 323 volts respectively is needed. Now, as our correspondent points out, the amplifiers in the adaptor each consist of a half of a 6N7, with a plate-supply voltage of only 300 volts. It is thus manifestly impossible for these valves, at this plate-supply voltage, to give enough output voltage to fully deflect the spot. With 2000 volts on the 5BP1, the situation is even worse, as it now takes 381 and 419 volts respectively to fill the tube.

With the 3AP1, at a final anode voltage of 1000, the deflection factors are 76 and 74 volts per inch, so that here, full deflection requires peak-to-peak voltages of 228 and 222 volts, which are more reasonable. In addition, the power supply circuit shown in the panoramic adaptor article will put only about 700 volts on the 3AP1 instead of 1000, so that the deflection factors are reduced in proportion, and the figures for the required p.-p. signal voltage are reduced to 160 and 155 volts. Now peak-to-peak voltages of this size can readily be supplied by the halves of a 6N7 acting as a resistance-coupled amplifier with an H.T. supply voltage of 300. Reference to the valve curves shows that, with a load resistance of 100,000 ohms, the maximum output voltage is 86 volts peak, or 172 volts peak-to-peak, confirming the above statement.

Using any other small valve in a similar circuit, but with the same H.T. voltage, will make very little difference to the available output voltage, as W.T.S. has found by bitter experience. If the H.T. voltage is to be kept the same, the only way to increase the output voltage is to install a phase inverter and feed the C.R.T. deflection plates in a balanced or push-pull manner. This will double the peak-to-peak voltages and will give 344 volts from a 6N7 with halves in push-pull. This should be enough for a 5BP1 with 1500 volts or less on its plate, and it will be remembered that such a deflecting system, with the identical tube, was used in the latest 'scope presented in these pages. If 2000 volts is used on the 5BP1, however, even this will not be enough, and the only cure will be to use a higher H.T. voltage. It is worth while remembering that in the R.C.A. Handbook, the values for the available output voltages of resistance-coupled amplifiers are given as **peak** voltages, but that, as far as the length of trace on an oscilloscope is concerned, it is the whole waveform, peak-to-peak, that we see, so that, for this purpose, the figures can be doubled. Then, if the resulting output voltage is not enough, using a push-pull stage will double the output voltage again. If this is still not enough, it is helpful to remember that increasing the H.T. voltage gives a proportionate increase in the output voltage, while leaving the voltage gain almost unaffected. For instance, the p.-p. output voltage of one-half of a 6N7 was quoted as 172 volts with a 300-volt supply. If the latter is raised to 400 volts, the output voltage will be increased by a factor of 4/3, making the new output voltage 230.

One puzzling feature of our correspondent's letter is that he has tried the Puckle cathode-coupled push-pull amplifier circuit without success, and yet this was the one used some years ago, quite successfully, in a 'scope circuit which we designed for a 5BP1.

The third trouble, that of insufficient R.F. sensitivity, was dealt with in a recent article, which showed how an extra stage of amplification, on 465 kc/sec., could easily be added ahead of the stagger-tuned input transformer. With this stage, using a 6BA6, in place, the sensitivity is more than enough, and the coupling condenser from the mixer stage in the receiver proper can be reduced to very minute propor-

(Continued on page 37.)

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RADIO COMPONENT MAKERS AND USERS

HOW CLOSER LIAISON HAS IMPROVED THE PRODUCT

By Thomas Roddam

(With acknowledgment to the "Wireless World," London.)

Professional engineers who are engaged upon component research and design represent in numbers only a very small fraction of those whose work depends upon radio components. This might be regarded as a commonplace; for instance, the number of broadcasting performers is very much smaller than the number of listeners. There is, however, an important distinction: if a soprano's voice cracks, the listener is no poorer. But if the components in a piece of equipment fail, the equipment designer, and not the component designer, is the immediate sufferer. He may not be the only sufferer, for the user may suffer either directly or indirectly. The equipment designer is certain to receive one of those sharp jolts which will remind him that life is real, life is earnest, and the grave's our only goal. Sometimes the equipment designer may find a component failure very costly.

This close dependence had led, before World War II to a very satisfactory, though largely informal, relationship between component manufacturers and equipment designers in the United Kingdom. In the background was a more formal structure. The British Standards Institution set up committees charged with the task of evolving specifications for what might be called the upper middle-class components. These committees were composed of both users and manufacturers, and it is unfortunate that they confined much of their attention in this field to externals. In addition, the three Service Departments had their own specifications for material which they considered suitable for use in equipment made for the armed forces. I shall have more to say of these later.

The spreading of the last war over a wide area of the world, and the change in the character of the war, led to a new situation. The demand for equipment increased much faster than anyone could have expected; the demand for components rocketed. Furthermore, the communications and radar equipment began to play a more important part. It became clear that an equipment failure could jeopardize not only the lives of the men using it, but the whole outcome of a tactical operation. This could even affect the strategic development of a campaign. Tank-to-tank communication, for example, provided the means of assembling detached units after a battle, and thus saving the whole force from being mopped up piecemeal. Reliable homing devices preserved the narrow margin of fighter aircraft strength in the summer of 1940. Complete reliability became of paramount importance.

PROBLEMS OF TESTING

The Service specifications had been drawn up in peace-time, when the equipment could have a rather "hand-made" air, for quantities were small. The new conditions led to the wholesale use of components of a quality which hitherto had been considered suitable only for broadcast receivers. The old specifications became meaningless, because they were written in a world which no longer existed. Acceptance testing, for example, had to be carried out on a percentage basis. One factory would have needed 200 tropical test chambers to carry out the tests on its full production, with corresponding numbers of test assistants and instruments. Clearly this was quite impracticable, and the manufacturer was simply ignoring this clause in the orders. Moreover, each Service demanded different tests, with different limits; many types of essentially identical components were being produced.

To clear up the situation, an Inter-Services Committee was set up, charged with the task of bringing the consumer's side of the component field into a satisfactory state. The sub-committees which actually did the work were essentially user committees. They stated what the performance of the components had to be for satisfactory functioning of the equipment then being designed. They studied properties of components and methods of testing them, and in the later stages they made a close examination of the statistics of production testing. Other groups made a critical study of the types and sizes of components, producing preferred lists and standardized sizes, so that no equipment should depend upon the output from one particular factory.

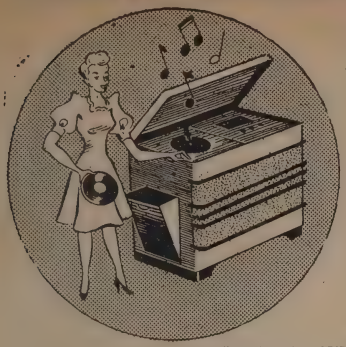
This work became more important as operations continued in remote parts, for the problem of component spares is greatly eased if common types are used in all equipments. This work is still continuing. The specifications and preferred lists are published by the British Standards Institution, and carry the general series number BS/RC. They are important documents, for they represent the considered views of a very large number of component users, moderated only in detail by the component manufacturers. Only the most obscure of trick circuits will require component performance not covered by this series of specifications; only at great expense can any sub-substantial improvement of all basic properties be obtained.

HIGHER-QUALITY COMPONENTS

So much for history; what of the present? One of the most interesting features of post-war equipment is the way in which the cheaper equipment has retained the well-finished look which is noticeable in Service equipment. The same is true of the components. They are now much better than they were ten years ago; there has been no rush to produce the really cut-price article. Partly this may be due to the fact that designers are now demanding higher quality, but it is mainly, in my view, because the component makers know that it pays to make the better goods. The equipment designer wants his equipment to sell, and to stay sold. If components let him down, he will switch to another manufacturer. This attitude can be seen in the contacts between the technical representatives and the designers; they are working together again even more efficiently than before, because the designer now knows much more about what can and cannot be produced.

One aspect of the component industry's approach to its problems always gives me pleasure. At component exhibitions the answers to questions are always technical and considered; the salesman, pure and simple, no longer exists. On the stands you will find the managing director, or the technical director, or someone else responsible, who knows all about

(Continued on page 47.)



For BIG SET *Construction*

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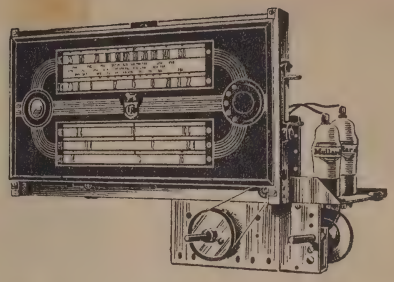

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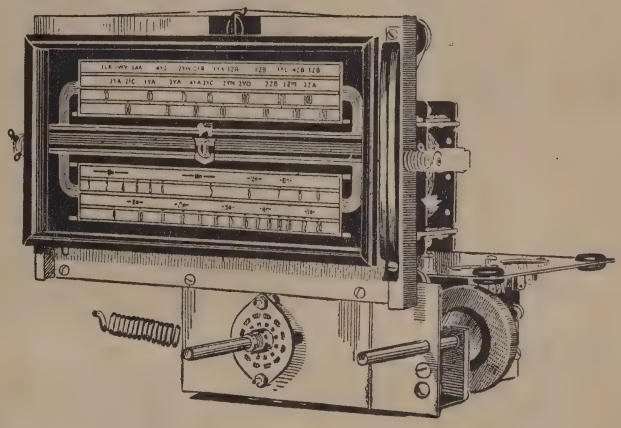

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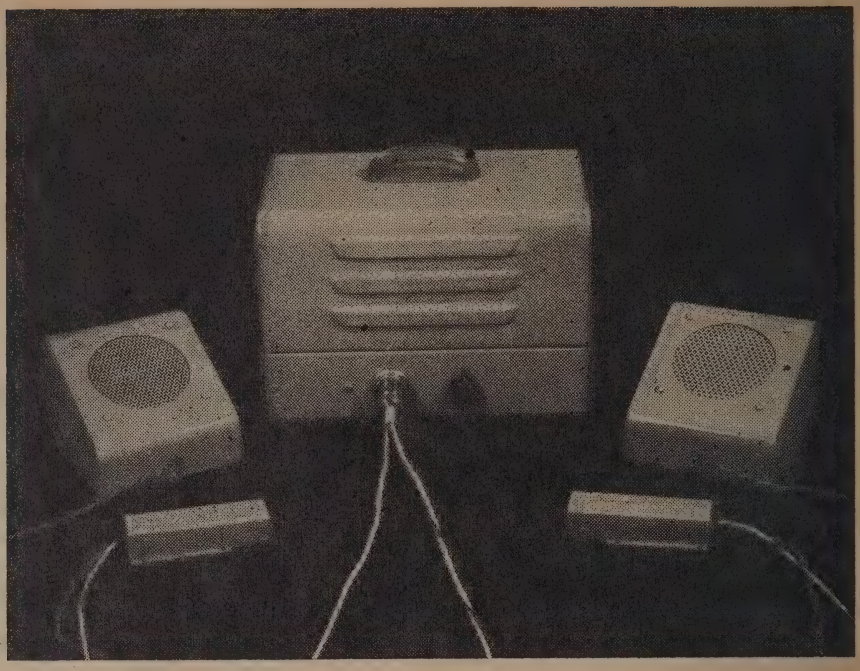
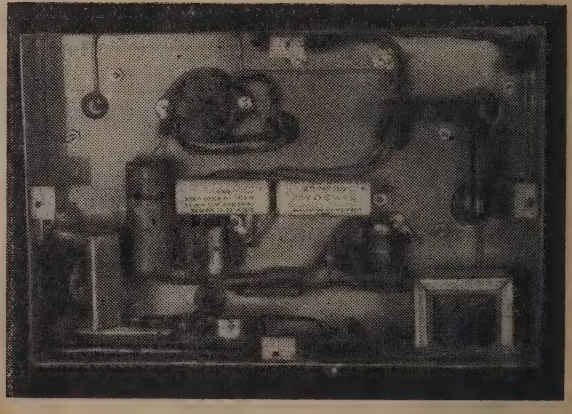
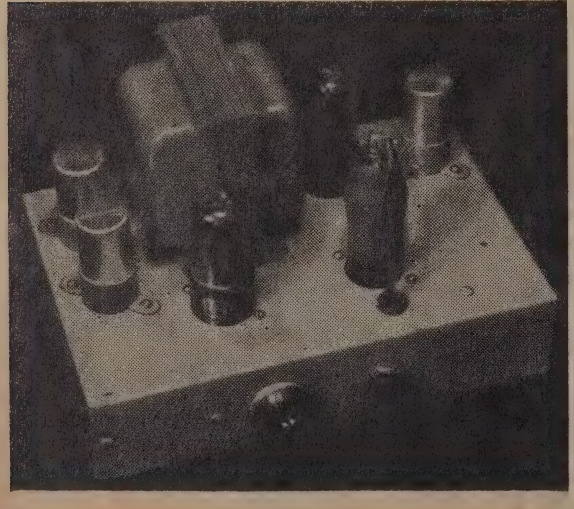


The photographs on this page give a good idea of the way in which the Radel Inter-com. set, whose circuit was described in our last issue, is built. The drawings given in the original article were used to make the chassis, speaker cabinets, and switch boxes. It will be seen that for the wiring from the amplifier to the two switch-boxes, a single shielded conductor, together with a single unshielded one, were used. These come together at the plug on the amplifier chassis, at which point the common earthing point for the input and output transformers is placed. It is important that the shield braid of the two lines should not come into contact with each other except right at the plug, otherwise the undesirable condition that we described last month will occur,





and oscillation will result.

In the under-chassis photograph, the placement of the input and output transformers can be seen. The output transformer can be seen on the front of the chassis at the right of the photograph. The input transformer was placed at an angle in the left-hand front corner (in the photograph), and was mounted on the skew because in our case this gave the smallest amount of hum pick-up. It does not follow that in any other arrangement the same results will be obtained, and it is a good idea to leave the screwing down of the input transformer to the last, when its position can be experimented with until the position for least hum is found.

We did not have recourse to any more drastic measures than this in order to reduce the hum to an acceptable level, but in bad cases there is a trick that can be tried, and which will almost certainly

effect a complete cure, assuming that the hum that is troublesome is that picked up by the input transformer. It is to remove laminations from the tranformer core until the hum disappears. This dodge is successful because removing iron from the input transformer has practically no effect on its sensitivity as such, while reducing enormously the effect of an external magnetic field. In order to make the most of this effect, it may be necessary to remove all but a few of the laminations, and, if this is done, it will also be essential to tighten the remaining ones by inserting small wedges of wood or other insulating material. However, we mention this process so that those who may have extreme difficulty in removing hum can use it. In general, there will be no need to do this at all.

In our own unit, we used a two-section resistance-capacity filter for smoothing instead of a choke, and the three 16 μf. electrolytic smoothing condensers can be seen in the top-chassis view. The wiring is quite straightforward, and the only place where care is needed is in the earthing of the whole circuit at one point, as was mentioned in the original article. The point chosen in our case was the earthing lug supplied with the three-contact microphone-type socket. The primary leads of the input transformer can be seen in the photograph, encased in spaghetti, so that the shield braid that covers them cannot touch the chassis until it gets right to the earthing point. If this is done, and if also the shielding of the leads to the switches is not allowed to touch except right at the plug, where they are soldered together, no oscillation trouble will be experienced. If any such difficulty is encountered, there can be only one cause, and all that has to be done is to track down the point at which the earths for input and output circuits have been allowed to become commoned, apart from the one place where this is done intentionally. It might seem to readers that we have rather laboured this point, but we have done so intentionally, because oscillation in a system like this can be so difficult to cure if the right answer to it is not known, and so easy if it is.

Beacon Technical Topics No.15

Power Transformer Specifications.—It is not always realized that the performance of a transformer, power or audio, is often influenced by circuit conditions outside the transformer itself. To specify the windings required and other physical characteristics of the transformer will not ensure that the expected operation will be satisfactorily obtained unless the associated circuit conditions have been examined and their effects allowed for. For instance, the voltage and maximum current of a power transformer working into a choke input filter will be quite different from that obtainable from the same transformer working into a condenser input filter.

For a condenser input filter, the rectified voltage available will be much higher than that obtainable from the same high-tension transformer used with a choke input filter. The wave shape of the current flowing through the windings is greatly different in the two cases. This effect means that the rectified output current available from a choke input filter is greater than that obtainable from a condenser input filter although the same receifier tube and high-tension transformer are used in each case. Approximately the same power output is obtainable from the two filter systems, but the ratio of current to voltage is quite different in the two cases. A further point to bear in mind when contemplating ordering a power supply transformer is that the manufacturers of rectifiers usually specify the maximum operating conditions for which their goods are designed. The type of filter system sometimes makes quite a substantial difference to the allowable transformer secondary voltage applied to the rectifier plates.

In the case of a half-wave rectifier, the R.M.S. current in the secondary winding of the transformer attached to the rectifier plate is considerably greater than the value of the direct current output. This factor influences the physical size of the transformer, making it somewhat larger than one would expect from a consideration of the rectified current and voltage alone...

BEACON designers are well qualified to cope with problems arising in the design of special transformers, but are at times unable to guess just what a customer has in mind when insufficient details have been supplied with the order for a new transformer. It often saves time and trouble if, when ordering a special transformer, full details of the use to which the transformer is to be put are supplied. A circuit diagram, a note as to the rectifier type, and a brief explanation of your requirements can be most helpful to the designer working on special orders. Elimination of guesswork leads to satisfaction on both sides. When ordering, be sure to include such details as type of mounting, vertical or flat, and the type of winding termination desired, as well as giving the more technical information about required electrical performance.

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DIVIDING NETWORKS FOR LOUDSPEAKER SYSTEMS

In these enlightened times it is an easy matter, comparatively speaking, to provide ourselves with a really excellent audio amplifier, at not too great a cost, which will give us all we may wish by way of power output, frequency response, and small distortion. Even so, there are many problems which confront the quality enthusiast; it is popularly supposed that the speaker is one link in the chain of reproduction that is outside the user's control, except in so far as the man with much money to spend is far better off than the one with a comparatively lean pocket. There is a somewhat natural tendency to assume that the high cost of the best speakers and speaker systems, coupled with the fact that the desire for the best possible reproduction knows no boundaries of place or pocket, is just one of those injustices of Fate that must be borne with as much fortitude as possible, and a stoical putting-up with the best speaker that can be afforded! However, this is not necessarily the case, and there are some dodges by means of which results can be obtained from moderately-priced equipment that are very little behind those got by the man who can blithely spend £40 or more on a good dual-unit speaker system!

One of these dodges has already been featured with much success in the pages of "Radio and Electronics"—namely, the bass-reflex or vented baffle. However medium, or even mediocre, the performance of a speaker when used in the kind of baffle provided by the usual type of radio cabinet, a very great improvement can be made by using a bass-reflex cabinet that is designed with the characteristics of the speaker in mind. There are many of our readers who will be able to agree wholeheartedly with this statement, from their own practical experience, and who will advise others who have not tried this system to get hold of a copy of "Radio and Electronics" for October, 1948, and get to work on the lines indicated in an earlier Design Sheet. However, the purpose of this article is not really to laud the performance of the vented baffle, but to present a second, equally effective dodge for improving our reproducing systems at very little cost to ourselves other than some easy and interesting construction work.

WHY USE A DIVIDING NETWORK?

For the uninitiated, perhaps we should detail just what a dividing network is and does, and why its use should give us such a noticeable improvement, and at such reasonable cost.

First of all, a dividing network is a circuit which enables us to use two speakers instead of one, and in such a way that one of them handles the middle and low-frequency range of audio signals and the other reproduces on the middle-to-high-frequency band. It might not be immediately apparent how this can help to reduce costs, but there is no doubt that on a performance-for-price basis, it most certainly can. Let us rather start by detailing some of the technical improvements that such a system can give us, compared with a single speaker handling the entire audio range from the lowest to the highest frequencies. Briefly, the main advantages are these:—

(1) Decreased Distortion:

It is not generally realized by audio fans that the conventional loudspeaker is the most prolific source of distortion that we may have to cope with, especially if we have a modern low-distortion amplifier. This distortion arises because of the inability of the speaker cone to reproduce notes of widely differing frequency without mechanical distortion of the cone itself, with consequent distortion of the sound we hear, despite the fact that the electrical input fed to it may be quite free from distortion.

(2) Increased Useful Frequency Range:

Because the intermodulation distortion referred to in (1) above is present in all single speakers to a greater or lesser extent, depending mostly on the quality of the speaker itself, it is found that to achieve a pleasant-sounding result, we have to limit the high-frequency range of the amplifier by some form of tone control. In other words, high-frequency response that is greater than usual is quite useless if intermodulation effects are present in the speaker, and even if we have a superlative radio tuner or gramophone tuner or pick-up, it is impossible to make the best use of it. In fact, the more extended the high-frequency response of the system IN FRONT of the speaker, the more objectionable are the effects of the speaker's own distortion. Thus, if we can do anything to reduce the distortion produced by the speaker cone itself. the improvement will be noticeable, not only for its own sake, but because of the indirect effects also. Reducing speaker distortion allows us to use a much wider response at the high-frequency end without any of the harsh, discordant effects, commonly described as "hash," which occur if we provide ourselves with an extended frequency range without at the same time dealing with distortion in that range.

These advantages should be sufficiently attractive to most amplifier builders to convince them that a dual speaker system is worth a trial, particularly when it is pointed out that the poorer the single speaker that they are putting up with because of the expense of a better one, the more marked should be the improvement noticeable when the dual system is tried. Up to date, one of the greatest difficulties for the amateur has been to find a suitable design for the all-important dividing network.

PURPOSES OF THE DIVIDING NETWORK

Assuming that we have convinced readers of the desirability of using two speakers instead of one, the question arises as to just what part the dividing network plays, and whether it cannot be dispensed with. Since our scheme is to feed only low frequencies to one speaker, and only high frequencies to the other, we must provide ourselves with a circuit which will ensure in practice this takes place. This is the purpose of the dividing network, and unfortunately, if the fullest benefit is to be had from using more than one speaker, it is an essential part of the system. Hitherto, not only has it been difficult for amateurs to design their own networks, but, assuming that this has been done successfully, a further difficulty arose. The network must use audio frequency chokes, as there is no simple way of performing the required frequency separation without them. Further, these chokes must have particular values of in-

ductance, which are related to the other fixed circuit condition, such as the voice-coil impedances of the speakers to be used, and a frequency, yet to be defined, but which is known as the cross-over frequency. The difficulty has been that amateurs—and, indeed, many professionals—have not the means of measuring the inductance of audio chokes once they have been wound, and, unless this can be done, to make sure that the values are correct, the system will not work properly.

PURPOSE OF THE ACCOMPANYING DESIGN SHEET

It is to remove this difficulty that the present chart is printed. For it we are indebted to Mr. E. B. Menzies, design engineer of Johns, Ltd., Auckland, who has performed the necessary practical work from which he has prepared the chart. It refers to a particular form of winding for air-core chokes, and covers a range of values that are likely to be met with in designing dividing networks. It is very simple to apply, because the information we are about to give tells the user what inductance is needed for his chokes, whereupon a reference to the simple graph tells how many turns must be wound, in the form shown, in order that the required inductance may be realized.

MANY POSSIBLE CIRCUITS

A further trouble to amateur designers has been the large number of possible circuits for dividing networks that have appeared in the literature. Between many of these there is very little to choose as far as performance is concerned, and yet some are much more complicated than others. What we have done here is to choose one of the simpler circuits which has been found quite satisfactory in practice. This is given in Fig. 1 (a), which is the one to which the following formulae refers. Fig. 1 (a) is suitable for all cases where the voice-coil impedances of the two speakers are the same. We will have something to say about the circuit of Fig. 1 (b) later, but at present it will be enough to indicate that it is used when the two speakers do not have identical voice-coil impedances, and that it is identical with the first circuit, except for the addition of a simple and inexpensive transformer.

Looking at Fig. 1 (a), it will be seen that it consists of only two chokes and two condensers. The chokes are identical, and so are the condensers, so that a simpler network would be difficult to find. The network has two input terminals, which are connected to the output terminals of the output transformer, which has not been shown. There are four output terminals, however, one pair for the high-frequency speaker and one for the low-frequency one. Supposing that the speakers both have 15-ohm voice-coil windings; the diagram shows that the network is attached to the 15-ohm winding of the output transformer, and that its output terminals are directly connected to the speakers. Thus, there is no need to buy a new output transformer, for, although two speakers are used, each of 15 ohms (or whatever value they may have), the network provides a match for a 15-ohm voice coil. If this was the impedance of the original single speaker, which will normally be one of the pair to be used, then no change in the output transformer is required.

Looking at Fig. 1 (b), it will be seen that this circuit contains an extra transformer. Suppose the low-frequency speaker has a voice-coil impedance of 15 ohms but that the high-frequency speaker has an impedance of only 3 ohms. The same network is used, as is shown by the chokes and condensers having the same labels as in Fig. 1 (a). Thus, the impedance at the output terminals for the high-frequency speakers is 15 ohms, but that of the speaker itself is only 3 ohms. All we have to do, therefore, is to provide a transformer which will

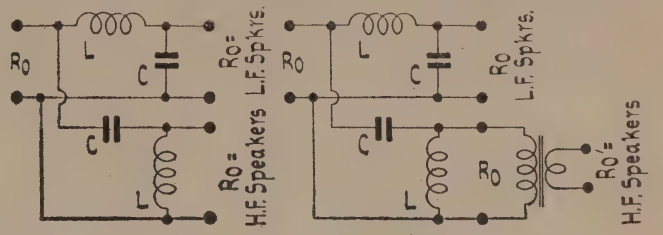

Fig. 1

match 15 ohms to 3 ohms, and insert it between the high-frequency speaker and the H.F. speaker's output terminals on the network. As will appear later, this transformer need not be a costly one at all, because it has to handle only the high audio frequencies, and also because it has to handle only a small fraction of the total power output of which the amplifier is capable. It can thus be quite small and cheap, even if high-fidelity results are expected.

DESIGNING THE NETWORK

How, then, do we go about finding what values must be inserted in the circuit of Fig. 1 in order to perform the frequency separation in the correct way? There are two main things that the network has to do, and these things decide for us what values have to be used. First of all, though, we have to decide for ourselves what the cross-over frequency is to be. The cross-over frequency is the frequency at which the inputs to the two speakers are equal. It is really the frequency at which we want one speaker to stop working and the other to take up, but, since it is impossible to make a network which cuts off dead at some particular frequency, there will in practice be a small range of frequencies, centred on the cross-over frequency, in which both speakers do a share of the work. This is shown quite clearly in Fig. 2, which illustrates the frequency response of a typical dividing network. Where the two parts of the curve cross is the cross-over frequency. It will be seen that the drop in response is quite sudden at both higher and lower frequencies, and amounts to approximately 10 db. per octave. There are good reasons for having a cut-off that is as sharp as this, and also for having one which is very little sharper, if any. Thus, the performance illustrated has the advantage of being the best practical compromise, and at the same time being quite easy to realize with the kinds of choke and condenser that are available.

WHAT GOVERNS THE CHOICE OF CROSS-OVER FREQUENCY?

At first sight it might appear that any frequency round about the centre of the audio range would be a suitable one, but this is not the case. There is a best value of cross-over frequency, and it has not necessarily anything to do with the speakers that

are used.

In commercially designed and manufactured twin-speaker systems, it is usual to use two quite different kinds of speaker for the high and low ends of the scale. This is because the best type of low-frequency speaker is a large cone-type one, such as we normally must use for all frequencies at once, and the best type of high-frequency speaker is the small-diaphragm kind with a multi-cellular horn attached to it to spread the "highs" through the room without any pronounced beaming effect. We however, will not in general be using these, but will have to make do with, say, a good 12 in. cone speaker for the "woofer," or low-frequency speaker, and a small 6 in. or 8 in. ordinary speaker for the

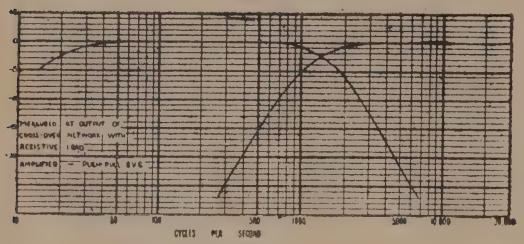

Fig. 2

"tweeter." This works very well indeed, and will give us almost as good results as a special tweeter as long as we mount it properly. The point at issue is now this, that our amplifier, for the sake of argument, can put out 15 watts. The 12 in. speaker, say, can handle this amount of power, but no ordinary 6 in. or 8 in. unit was ever designed to handle as much as this. Our scheme would therefore appear at first sight to be pleasantly inexpensive, but impossible. Such, however, is not the case. It has been ascertained by dint of much special research that when we listen to a symphony orchestra, for example, THE GREATEST POWER OUTPUT THAT ASSAILS OUR EARS LIES BELOW 1000 CYCLES PER SECOND. Better than this, the relative amount of **power** that is given out at frequencies higher than this is very small indeed. Thus, if we choose our cross-over frequency correctly we arrange for practically all the power to be handled by the low-frequency speaker, and only a small amount to be fed to the high-frequency one, without in any way disturbing the balance between lows and highs, or making things sound unnatural. Thus, it becomes quite practical to use only a very low-powered speaker for the high-frequency range, and our idea of a 6 in. tweeter is not ruled out at all. And because a small speaker is usually better at reproducing the high frequencies than a large one, we gain still further over the single-speaker arrangement.

The curve given in Fig. 3 shows a typical curve of power versus frequency for an orchestra. It will be seen that the peak in the curve is quite sharp at about 400 c/sec., and that on either side of this the power falls away fairly rapidly. At 1000 c/sec., the power has dropped to less than 20 per cent. of that at 400 c/sec., so that if a small speaker is to be used for the tweeter and the cross-over frequency is to be 1000 c/sec., only a fifth of the maximum power output of the amplifier needs to be handled by the small speaker. Thus, with a 15-watt amplifier, the tweeter need not be able to handle more than 3 watts, so that a single 6 in. speaker (of one make) or three 3 in. speakers (1 watt each) of the same make would be ample. If the cross-over frequency is made a little higher than 1000 c/sec., there will be ample leeway for emergencies.

The choice of cross-over frequency is not critical, as can be seen from the distribution curve, but it could be kept reasonably low, so that the greatest benefit will arise from the separation from the high frequencies of the lows which cause the worst inter-modulation effects. A useful compromise is between 1000 and 1500 c/sec. Within these limits, one can

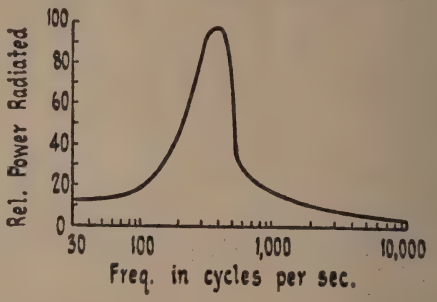

Fig. 3

please oneself, and choose the frequency finally from other considerations, among which are the ease with which the necessary chokes and condensers for the filters can be got or made up.

FORMULAE FOR L AND C

The values of L and C can very easily be worked out from the following formulae, once the speakers to be used, and also the cross-over frequency, have been decided upon.

The choke should have an inductance of L millihenries, where

$$L = \frac{226 R_o}{f_c} \text{ mH.}$$

In this formula, R_o is the voice-coil impedance in ohms of the speakers to be used, and f_c is the cross-over frequency in cycles per second.

The condensers should have a value of C μf., where

$$C = \frac{113{,}000}{f_c . R_o} \mu\text{f.}$$

In this formula, R_o is again the voice-coil impedance of the speakers and f_c is the cross-over frequency, in cycles per second.

For those who may not be very happy about working out such formulae, we will work out a common example. We have decided on the following:

(1) The speaker voice-coil impedance is 15 ohms;

(2) The cross-over frequency is to be 1250 c/sec..

We then have

$$L = \frac{226 \times 15}{1250} = 2.8 \text{ millihenries, and}$$

$$C = \frac{113{,}000}{1250 \times 15} = 6.0 \text{ microfarads.}$$

Now, let us take an example where the cross-over frequency does not change, but where the impedance

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is widely different, at, say, 500 ohms. Not that any normal speaker is wound for such a high impedance, but the calculation will serve to show what sort of values are obtained for L and C for higher impedances.

Applying the formulae in the same way as before, we get

$$L = 93 \text{ mH., and } C = 0.18 \ \mu f.$$

The important things to notice about the altered sizes of the choke and condenser are that—

(a) Raising the impedance raises the value of L; and

(b) Raising the impedance lowers the value of C. If anyone should be energetic enough to work it out from the formula, it will be found that both 2.8 mH. and 6.0 μf. and 93 mH. and 0.18 μf. resonate at 1250 c/sec., which is the cross-over frequency. It can be seen that from the point of view of ease of construction, raising or lowering the impedance at which the network operates affects the values of C and L in opposite ways. Unfortunately, we have very little choice about the impedance level, since this is determined by the voice-coil impedances of the speakers that we decide to use. Also, at low impedances, such as we are likely to have to use, the condensers become quite large in value. This might not appear to present much difficulty, until it is realized that under no circumstances can electrolytic condensers be used in a dividing network. In some articles on the subject one can find statements to the contrary, but doing so is very definitely bad practice, for a variety of reasons. Paper-dielectric condensers must be used, and the only saving grace is that their voltage rating need only be very low. However, large paper condensers are not easy to come by, since the largest made in the tubular type common to radio circuits is 1 μf., and to make the capacities up from these is quite expensive. Luckily, however, there are on the market 4 μf. 500 volt condensers, which are quite inexpensive, and which can be used together with others in parallel to make up the necessary capacity. For ease of getting the necessary capacity, it pays to use a high cross-over frequency, and when this is done it is found that a smaller choke is needed, too. However, as stated above, for best performance, the cross-over frequency should not be too high, so there is a limit to what can be done by this means.

OBTAINING THE NECESSARY CHOKES

With the aid of the accompanying chart, the chokes are perhaps the easiest part of the circuit to come by, in spite of the fact that they have to be home made. However, certain firms who specialize in audio transformers will no doubt wind chokes to specification if asked. As far as home winding is concerned, the job is made easier, if more laborious, because of the fact that it is not practicable to use iron-cored chokes in the ordinary way. The losses in them have to be kept down, and this means winding them of heavy wire, in addition to keeping iron cores out. This makes even a small choke quite bulky, but makes winding easy, as a simple layer-wound type is quite satisfactory. Luckily, we do not have to worry unduly about self-capacity. It might be thought that when a low-inductance choke of only a few millihenries is needed, it would be possible to use something after the style of an R.F. choke designed for the broadcast or shortwave range, but this is not the case, because of the high resistance of such chokes. The 20 or 30 ohms that they normally have makes them quite impossible for voice-coil circuits where the currents are to be reckoned in amps rather than in milliamps. The Q of the filter circuits has to be as high as possible, otherwise the losses are excessive, and only a fraction of the power output is actually delivered to the speakers.

The Design Sheet No. 9, from which the correct winding form and number of turns for arriving at the required inductance for the chokes, will be found on page 35, and once the network has been calculated from the above formulae, the chokes can be constructed according to the chart.

ADJUSTMENT OF THE NETWORK

Unless some test equipment is available, it will not be possible to make any adjustments to the network once it has been constructed, and, in general, this will not be necessary. However, if one has an audio oscillator and an oscilloscope or V.T. voltmeter, it is a simple matter to check that the network is working properly. To do this it is only necessary to take a response curve for each pair of output terminals, by attaching the dividing network to the amplifier, connecting on the speakers, and running through the audio scale with the audio oscillator. The curves plotted should cross at the designed cross-over frequency, and the attenuation above and below this frequency should be approximately 10 db. per octave. That is to say, after the initial rounded portion of the curve, the drop should be approximately 10 db. for a twofold frequency change. There is no need to worry unduly about the accuracy of the chokes and condensers, as this can affect the performance only slightly as long as normal tolerances are struck. The worst that can happen is a slight change in the cross-over frequency, and a slight mismatch for the speakers, and neither of these is as important as one might expect. There has to be a very bad mismatch before the power output is noticeably affected, and even 20 per cent. error in both condensers and chokes can only cause a similar change in cross-over frequency, which will not be at all serious as long as the intended cross-over point was not too low in the first place.

PHASING OF SPEAKERS

When the network has been constructed, it is essential to see that the speakers are properly phased, or the performance in the middle range, where the two speakers are each providing a portion of the output, will not be correct. The speakers must be connected so that their output in this range adds, and does not cancel. This is easily attended to by tapping a 1.5 volt battery on to the input terminal of the amplifier and watching which way the cones of the speakers deflect. If the cones move in the same direction, the phasing is right, but if in the opposite directions, it will be necessary to reverse the voice-coil leads of one speaker—it does not matter which. If both are reversed, we will end up where we started and be no better off.

USE OF SPEAKERS OF DIFFERENT V.C. IMPEDANCES

The cases we have worked out to illustrate the use of the formulae were both on the assumption that both speakers had the same voice-coil impedance. If they have not, the circuit of Fig. 1 (b) is used, and an extra transformer will be needed, as explained. It will be noted that the case shown in

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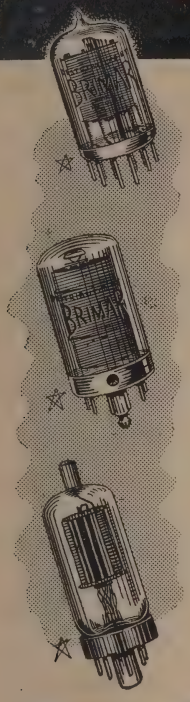

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6.3-volt Loctal Types	7H7	7S7	7H7	7K7	7C5	7Z4
6.3-volt Octal Types	6K7GT	6K8GT	6K7GT	6B8GT	6V6GT	5Y3GT
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Fig. 1 (b) is for a tweeter whose impedance is lower than that of the woofer, and this is the case that will usually be met with in practice. However, should the reverse be the case, the circuit is the same as before, with the exception that the transformer will now have to provide a step up in impedance from the network to the H.F. speaker. There is only one rule to be remembered, and that is **always design the network as if both speakers had the impedance of the low-frequency one, and then use a transformer to step up or down from that impedance to that of the H.F. speaker.** This rule is made because, for economy's sake, the transformer should always be in the high-frequency leg of the circuit, and designing the network in this way ensures that it always is, regardless of the two speaker impedances. For instance, it would be possible to design the network for the impedance of the H.F. speaker, and then place the transformer between the L.F. output terminals and the L.F. speaker, but if this is done, the extra transformer has to handle the low frequencies as well as the main output transformer, and would vastly increase the cost of the whole system if high-fidelity results are wanted.

USE OF MORE THAN ONE H.F. SPEAKER

There is no reason why the system should use only two speakers. By this we do not mean that we should split the audio range into three by means of a more complex dividing network, but that it is sometimes an advantage to use two or more small speakers in series or parallel instead of just one, for the high-frequency speaker. The advantages of so doing are (1) that small speakers such as are most likely to be used for the tweeter are almost all of 3 ohms impedance, which is much lower than that of the better 12 in. speakers that have been sold in quite large numbers recently. If the impedance of the L.F. speaker is much higher than this—say, 15 ohms, which is a common value—one would have to put five small speakers in series in order to avoid the use of the extra transformer. But this trick can be used in some cases. For example, one well-known 12 in. speaker has an impedance of 7 ohms. Now, rather than use a step-down transformer between the network and the H.F. speaker of 3 ohms, it would be preferable to use two 3-ohm speakers in series as the H.F. unit. This would give a total impedance of 6 ohms, which is near enough to 7 ohms to eliminate the extra transformer.

There is another advantage in using more than one H.F. speaker. The cone speaker normally produces quite a well-defined beam at high frequencies, which means that the response of the system varies according to one's position in the room. This is quite noticeable with a single 12 in. speaker, and is to be avoided if possible. The commercial method of so doing is to use the aforementioned multi-cellular horn type of tweeter, but this is out as far as the average amateur is concerned. However, a considerable improvement in the H.F. distribution can be effected by using more than one H.F. speaker and pointing them in slightly different directions. Three of them are even better than two, and they can be connected in series, giving a closer match to the network than one would do. The extra transformer will still be needed if the added-up impedances do

(Concluded on page 48.)

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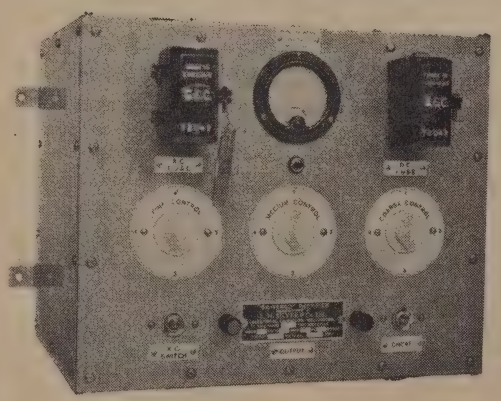

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AUDIO EQUIPMENT AND DESIGN:

Modernizing a Remote Amplifier. Circuit and construction of an audio amplifier for which is claimed a frequency response flat within 2 db. from 20-20,000 c.p.s. 1620 type valve used in low-level stages, transformer input, 1620 mixer, 6SN7 voltage-amplifier-phase splitter, and 6SN7 p.p. output.

—Communications (U.S.A.), April, 1949, p. 14.

ANTENNAE AND TRANSMISSION LINES:

Directional Antenna for the 152-162 mc. Communications Band. Details of a corner reflector type of vertically polarized antenna having a gain up to 6 db. over half-wave dipoles. Radiation patterns shown and back-to-front ratios measured. Possible to feed with 50-75 ohm air dielectric and solid dielectric cables.—Communications (U.S.A.), March, 1949, p. 14.

A 16-Element F.M. Receiving Antenna. Details of construction.—Communications (U.S.A.), April, 1949, p. 8.

General Folded-Dipole Antenna Design. Analysis of field patterns and radiation resistance. Folded-dipole design considered in general. Comparison of theoretical with experimental results.

—Communications (U.S.A.), April, 1949, p. 18.

CIRCUITS AND CIRCUIT ELEMENTS:

Transfer Functions for R-C and R-L Equalizer Networks. Ratio of output to input voltage in tabular form. Thirty types of network, with respective transfer functions and gain curves. Phase angle between input and output voltages shown.

—Electronics (U.S.A.), May, 1949, p. 116.

30 kv. D.C. Regulated Power Supply. Circuit employing: (1) Low-voltage transformer in full-wave rectifier circuit delivering 450 volts at 250 ma.; (2) R.F. oscillator with three parallel 6L6 valves; tickler circuit oscillator generates frequency of approximately 200 kc.; (3) high-voltage rectification with three 8016 valves cascaded as voltage tripler; (4) automatic regulation by use of 6SH7 pentode in conjunction with gas-regulator valve operating as sampler of portion of high voltage. Amplified sample voltage is fed to 6L6 as control amplifier. The last-mentioned valve, in conjunction with a regulator valve, supplies anodes and screens of oscillator valves with appropriate additive or denial voltages. Claimed for the unit that voltage is adjustable between 25-30 kv. at regulation better than 1 per cent. with varying load limit of 1 ma. and input mains voltage variations from 95-125 volts.

—Radio News (Radio Elect., Eng. ed.) (U.S.A.), May, 1949, p. 16.

Simple Tone Control Circuit. Circuit of tone control system adaptable to audio amplifiers and requiring resistors and capacitors as only extra components, with possible addition of extra triode in some cases to give requisite gain. Circuit provides bass and treble cut and lift. Bass control approximating plus 10 db. to minus 12 db. at 50 c.p.s., and treble plus 10 db. to minus 16 db. at 6,000 c.p.s.

—Wireless World (Eng.), February, 1949, p. 48.

Electronic Circuitry. (1) Modified "Cascode" circuit to produce a low-noise R.F. amplifier by addition of extra triode valve constituting load in anode circuit of first valve, a triode. Possibilities of circuit as D.C. amplifier referred to. (2) Long delay relay; for use when mercury vapour valves and thyratrons employed and it is necessary for application of high-tension voltage to be delayed until filaments heated.

—Wireless World (Eng.), February, 1949, p. 51.

Single-valve Frequency Modulated Oscillators. Explanation of a newly-developed method of direct reactance modulation of an oscillator, which gives constant amplitude over a wide frequency range without necessity for phase-shift networks. Principle applied is alteration of effective value of an impedance by ensuring that the voltage applied to the impedance is only a definite fraction of the whole, whilst the current remains constant. In practical circuit, main tuning inductance is in cathode circuit of a pentode valve and a mutually inductive coil in anode circuit, modulates the effective value of the main inductance. In this case the current is divided instead of the voltage. A phase-inverting coil, acting as an auto-transformer, and suitably damped, is tuned to central oscillation frequency and produces oscillation. The last-mentioned coil is in series with grid, modulator coil, and anode. The oscillatory current thus flows in series with main tuning elements, which is a necessary condition in this circuit.

—Wireless World (Eng.), April, 1949, p. 122.

Electronic Circuitry. (1) Voltage stabilizer for CR tubes when potentials in excess of 750v. employed; (2) cathode-follower pulse stretcher.—Wireless World (Eng.), April, 1949, p. 126.

Grid Current with R.C. Coupling. Analysis of effects of valve drawing grid current when a square wave is fed through to valve by capacitance coupling. In multivibrator circuits such grid current produces voltages which determine minimum value of coupling condensers.

—Wireless Engineer (Eng.), April, 1949, p. 113.

Valves with Resistive Loads. Derivation of expressions for maximum undistorted output voltage which a valve can deliver when the load is purely resistive and H.T. supply is of a given value. Case of cathode-follower is discussed, but expressions arrived at are not inapplicable to circuits where load is in the anode circuit.

—Wireless Engineer (Eng.), April, 1949, p. 119.

FREQUENCY MODULATION:

Build Your Own 10.7 mc. Discriminator Transformer. Description of method of constructing discriminator transformers for F.M. reception.—Radio News (U.S.A.), May, 1949, p. 59.

Alignment of F.M. Receivers. Description of methods used in alignment of F.M. receivers, using oscilloscope and F.M. signal-generator. Covers receivers using limiter and discriminator stages and ratio detectors.

—Service (U.S.A.), March, 1949, p. 12.

MICROWAVE TECHNIQUES:

Simple Gear for the 420 mc. Beginner. Circuits and details of transmitter and receiver for the 420 mc. (amateur) band. Transmitter consists of 6C4 valve in speech amplifier circuit, 6AQ5 modulator, and 6J6 in p.p. output, using tuned half-wave anode lines. Receiver employs similar anode lines in 6J6 super-regenerative circuit. Equipment is simple in design.

—QST (U.S.A.), May, 1949, p. 11.

Beam-deflection Mixer Tubes for U.H.F. Interesting description of experimental beam-deflection valves and explanation of their mode of operation as amplifiers and mixers up to 900 mc., with improved signal-to-noise ratio, gain, and local oscillator radiation.—Electronics (U.S.A.), May, 1949, p. 76.

400 mc. Oscillator and Subminiature Tube. Circuit and constructional details of a 400 mc. oscillator using type 5703 valve. With circuit shown 446 milliwatts output obtained at 720 mc., using same type of valve.

—Electronics (U.S.A.), May, 1949, p. 122.

MEASUREMENTS AND TEST GEAR:

Stable Ten-light Decade Scale. Circuit and description of unit counting up to 200,000 counts per second. Power supply need not be regulated and wide variations in mains voltage tolerated. Circuit uses ring of five binary elements with a following scale-of-two stage. Additional advantages of circuit are that wide variations permitted in pulse, height, and shape, and considerable tolerance is permitted in values of capacitors used.

—Electronics (U.S.A.), May, 1949, p. 85.

Wide-range Deviable Oscillator. Description of unit suitable for use with oscilloscope for testing amplifier systems in F.M. and TV receivers. Design considerations discussed. Three circuits produced. Basically, unit consists of amplifier and four cascaded cathode-followers in a phase-shifting system, each stage producing 45 degrees of shift. The shift per stage is produced by making the capacitative reactance of each stage equal to the equivalent resistance of that stage. Frequency modulation is accomplished by varying the anode current of all c-f stages simultaneously.

—Electronics (U.S.A.), May, 1949, p. 96.

Standard Broadcasts from Hawaii. Reference to fact that Station WWVH at Hawaii, established by National Bureau of Standards (U.S.), is broadcasting on experimental basis continuous time and frequency standards on 5, 10, and 15 mc.

—Electronics (U.S.A.), May, 1949, p. 134.

A Linear Recording Meter. Circuit and construction of a unit in which linear movement of recording pen is controlled by D.C. signal (0-10 volts) changing one cycle per minute. Points of similarity between equipment described and servomechanism are dealt with.

—Radio News (Radio Elect., Eng. ed.) (U.S.A.), May, 1949, p. 8.

A Novel Plate-dip Oscillator. Circuit and constructional details of instrument which may be adapted to various uses, such as signal-generator, field-strength meter, absorption frequency meter, harmonic checker, parasitic indicator, and phone monitor. Employs 6J6 valve as negative-resistance type of oscillator. With plug-in coils gives continuous coverage from 3-160 mc., in seven ranges. Power supply is separate unit.

—Radio News (U.S.A.), May, 1949, p. 42.

A Dual-purpose Frequency Meter—V.F.O. Circuit and construction of a unit having 6SK7 E.C. oscillator, 6F6 isolation stage, and 6L7 valve as mixer. Used as V.F.O., unit will drive 807 valve either as straight amplifier or as frequency multiplier. Suitable stability gained by careful construction of E.C.O. to obviate necessity for usual 100 kc. crystal and associated circuit when unit operated as frequency meter.

—Radio News (U.S.A.), May, 1949, p. 56.

H.F. Transmitter for D.F. Measurements. Details of method of determining polarization error of a direction-finder. Transmitter is modulated and covers 3-20 mc/s. in three ranges. Transmitter is elevated and energizes a loop aerial, which may be rotated about a horizontal axis and produces any desired polarization. Design principles for aerial discussed.

—Wireless Engineer (Eng.), April, 1949, p. 124.

An Additive Frequency Meter. Circuit and construction of an instrument capable of measuring frequency in any portion of spectrum where harmonics of 100 kc. crystal oscillator may be heard. Output of 100 kc. oscillator is fed to mixer; output of variable frequency oscillator covering a 50 kc. range is also fed to mixer and modulates each 1000 kc. harmonic. Resulting sidebands may then be used in same way as output from orthodox frequency meter. This interpolation system has numerous advantages over usual methods.

—QST (U.S.A.), May, 1949, p. 32.

PROPAGATION:

Ionosphere Review: 1948, with forecast for 1949.

—Wireless World (Eng.), February, 1949, p. 56.

Range of V.H.F., Part 2: Ground Communication. Comparison of ranges obtained on different wavelengths, with different powers, using aerials of varying heights. Charts show range in miles over land and over sea, and losses due to various factors. Measurements were taken on 30, 80, and 160 mc/s.—Wireless World (Eng.), April, 1949, p. 124.

Ground Absorption. Consideration of behaviour of elevated vertical and horizontal dipoles in free space over imperfectly reflecting ground. Particular reference to (a) radiation resistance; (2) proportion of radiated power absorbed by the ground. Results presented in graphical form for practical use. Evaluation of noise in aerial system caused by thermal radiation from the ground.

—Wireless Engineer (Eng.), April, 1949, p. 133.

RECEPTION AND RECEIVERS:

Regenerative Shortwave Receiver in Miniature. Receiver to cover 5.5 to 18 mc., using 6AU6 valve as R.F. amplifier, 6AU6 as regenerative detector, 6C4 audio and 6AK6 output valve.—Radio News (U.S.A.), May, 1949, p. 62.

TELEVISION:

Television Front-end Design, Part 2 (and final article). Derivation of design equations for cathode-coupled R.F. amplifier and mixer stages (a) pentode, (b) grounded-grid, and (c) cathode-coupled, with and without preceding R.F. stage, which may itself be either of the three classes mentioned above. Operation of 6AK5, 6J4, and 6J6 valves in these circuits summarized in tabular form.

—Electronics (U.S.A.), May, 1949, p. 106.

TV Projection Systems. Description of current U.S. practice to obtain larger images.

—Radio News (U.S.A.), May, 1949, p. 47.

Directory of TV Receiver Manufacturers. Alphabetical list of 134 U.S. manufacturers and their respective business address.—Radio News (U.S.A.), May, 1949, p. 46.

Modern Television Receivers, Part 14. Complete analysis of design and operation of intercarrier TV sound systems (U.S. practice).—Radio News (U.S.A.), May, 1949, p. 64.

Superheterodyne Television Unit. Circuit of a receiver intended to have longer range than original Wireless World TV Receiver (originally described, serially, in January, February, March, May, July, August, September, October, November, and December, 1947, issues).

—Wireless World (Eng.), February, 1949, p. 61.

Television Interference by Aircraft. Explanation of causes of interference and suggestions for modification of video amplifier circuit in order that interference may be eliminated.

—Wireless World (Eng.), April, 1949, p. 142.

TRANSMISSION AND TRANSMITTERS:

A Brief-case Ham Portable. Circuits and construction of compact transmitter-receiver designed for C.W. or phone. Transmitter section comprises 1S4 valve in crystal-controlled circuit. Receiver employs 1T4 valve as regenerative detector and 1S4 amplifier. Designed for 80 and 40-metre (amateur) bands. Operates from dry batteries.

—Radio News (U.S.A.), May, 1949, p. 54.

Linear R.F. Amplifiers. Discussion of design and adjustment of linear amplifiers, such as are used in single-sideband transmission.—QST (U.S.A.), May, 1949, p. 15.

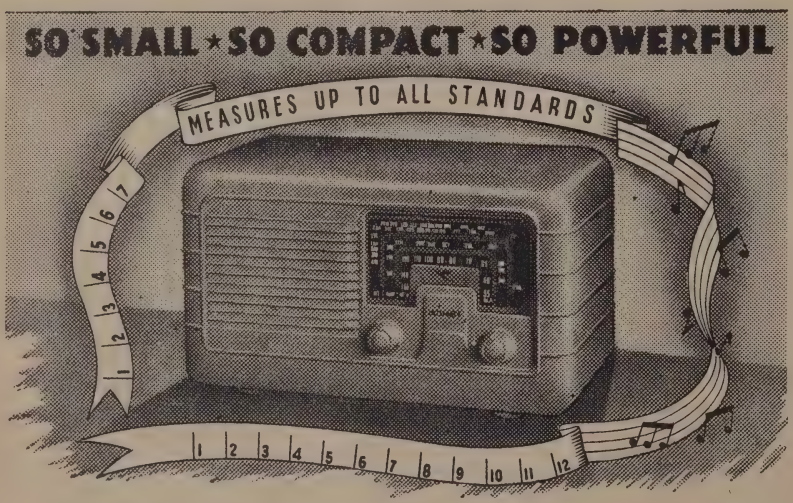
Band-pass Circuits in a Multi-band Transmitter. Circuit and construction of a transmitter consisting of a series-tuned V.F.O., 6AG7 buffer-doubler, 6AG7 amplifiers, and 807 final amplifier. In final amplifier circuit a 6V6 valve, used as a "clamper," is incorporated as a means of limiting D.C. input when excitation is removed. Frequency changing is possible with tuning controls reduced to a minimum by use of low-C. tank circuits, heavily loaded. Band-pass circuits are included to eliminate spurious radiation. Design and details of construction of filters.—QST (U.S.A.), May, 1949, p. 21.

MISCELLANEOUS:

Modern Vacuum Pump Design. Detailed description of vapour type pump which meets exacting requirements of TV C.R.T. manufacturers. Reference to automatic controls.

—Electronics (U.S.A.), May, 1949, p. 90.

(Concluded on page 48.)



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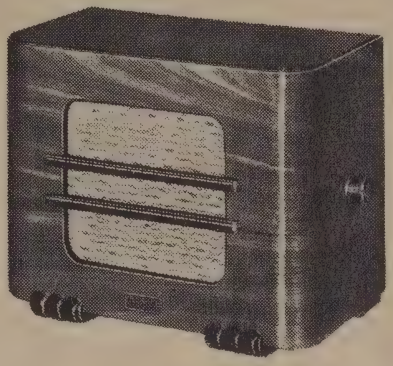

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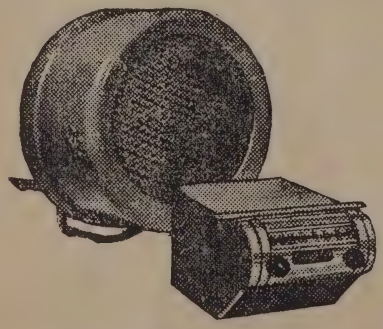

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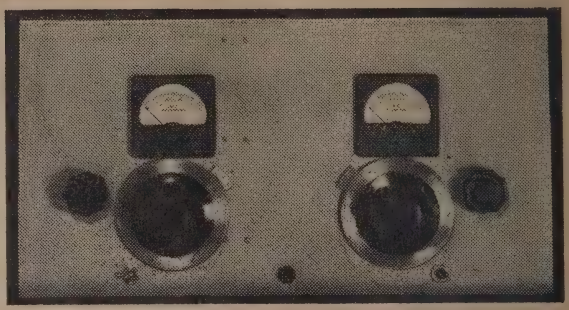
The PHILIPS Experimenter

No. 22: A FINAL AMPLIFIER TO FOLLOW THE ALL-BAND EXCITER—Continued

Last month we gave the preliminary data on the final amplifier that has been designed to follow the all-band exciter that has been the subject of recent Experimenters, thus completing the R.F. end of a 100-watt amateur transmitter designed round the latest Philips transmitting valves. This month we continue the story of the final, and show a number of photographs which describe the construction better than a large number of words. Also to be found in this issue are working drawings for the panel and chassis for the final.

GENERAL CONSTRUCTION

The photographs on this and the next page give a good idea of the general construction of the unit. The panel is standard relay width and is 10 in. high. Since so little of the construction is found underneath the chassis (as can be seen from the underneath view), this is only 1½ in. deep. Fig. 2 shows how the main parts are mounted above the chassis, including both tuned circuits and the QQE06/40. It will be noted that two shield partitions have been used. One of these has the valve socket screwed to it, while the other has shielding as its only function. It is mounted ¾ in. from the first one, so as to be level with the internal shield-plate inside the valve. The three Belling-Lee banana sockets that can be seen at the left of the grid condenser are for the plug-in grid coils. In this view it is difficult to see the similar sockets which mount the plate coils, but these can be seen quite clearly in the large photo of the plate circuit end of the chassis. Here can be seen the wide perspex strip above the plate tank condenser, and it is on this strip that the sockets for the plate coils have been mounted. None of the photographs shows the coils in position, but these were omitted from the photographs so as to make the construction visible. The plate tank condenser is mounted upside down on the distance-pieces made from brass tubing, and smaller distance-pieces are placed above the condenser's mounting lugs to act as supports for the wide perspex strip. Figs. 4 and 5 show the way in which the plug-in input and output links are mounted on the swinging arms. The output link is plugged into two banana sockets, carried on a small strip of perspex. The latter is fixed on the ends of two square brass rods which are bored at their lower ends to take the quarter-inch operating shaft. Not shown in the photograph are the two screws that hold these square arms to the operating shaft, as these screws are underneath the arms, whose lower ends are threaded to take them.



The front-panel view (Fig. 1) shows rather close proximity of the meters and the dials below them. In the prototype this arose through the non-availability of a smaller diameter dial which it was intended to use. Constructors should therefore vary the front-panel punchings for the meters in accordance with the dial diameter and the meter dimensions they desire to use.

The mounting of the input link is similar, except that the perspex on which the sockets are mounted is screwed to a single short piece of brass rod. The latter is just long enough for the edges of the sockets to come flush with the operating shaft. The two views of the input link mounting that are seen in Figs. 2 and 5 should make the method of mounting clear, while the mounting for the output link can be seen in Fig. 4.

The swinging links are operated from the front panel by means of small epicyclic reduction drives, which can be seen in the back-panel views. The brackets for the far ends of the operating shafts are made from 16-gauge aluminium sheet.

The small parts are mostly mounted underneath the chassis, which is rather bare-looking in spite of this. The large wire-wound resistor is the screen dropping resistor, and next to it can be seen the plate choke. It might have been preferable to have this component above the chassis so that a shorter lead could have been taken from the centre tap of the plate coil to it, but it was difficult to find a suitable spot for it above the chassis. The lead from the centre connecting socket runs vertically down between the two stators of the tank condenser, and comes through the chassis just at the end of the choke. Thus, although the lead to the choke is a few inches long, the circuit is perfectly symmetrical, and no trouble has occurred because of this length of lead. The final has been found to be perfectly stable

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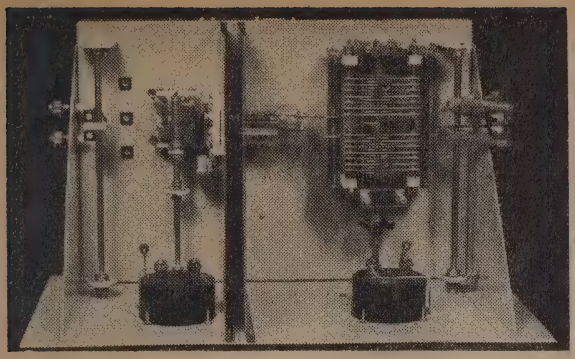

Fig. 2.—General view of the amplifier, showing the arrangement of the valve and tuned circuits. Note the two shield partitions.

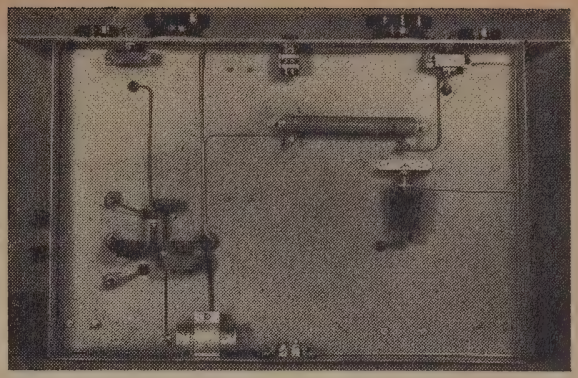

Fig. 3.—Underneath view. All small parts except the screen bypass condenser are under the chassis.

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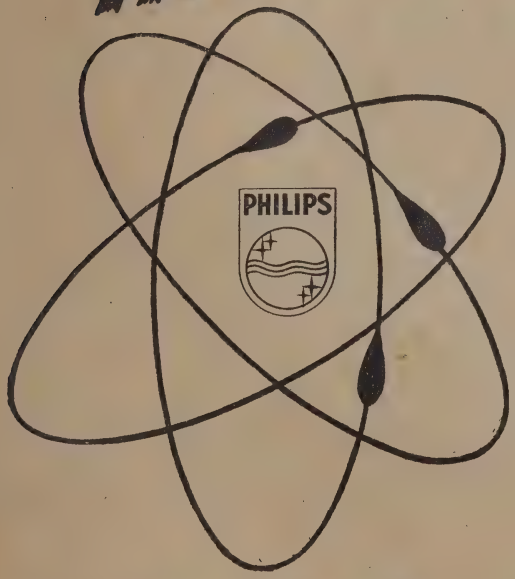

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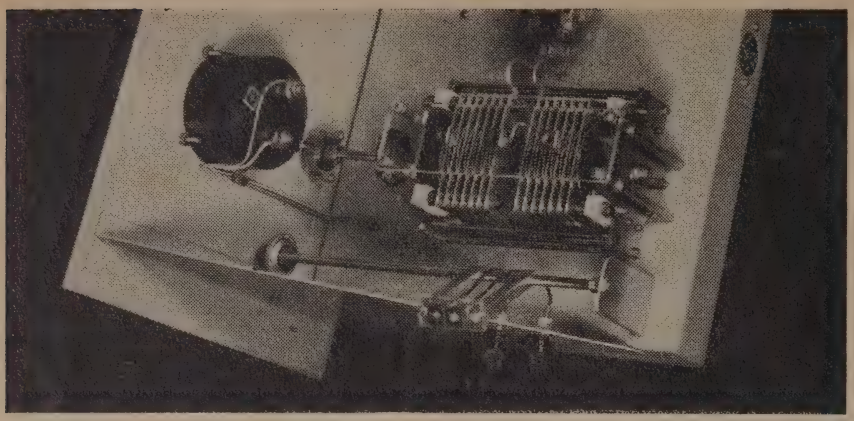


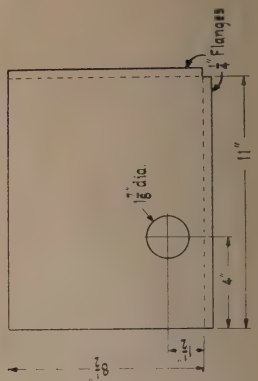
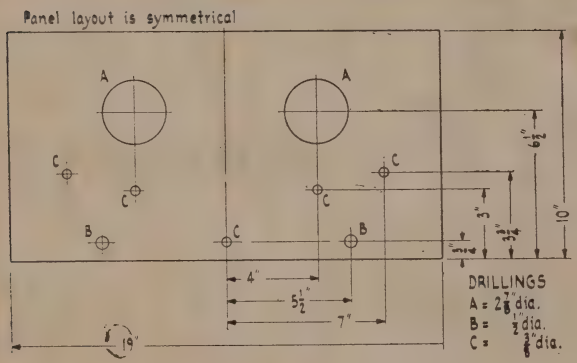
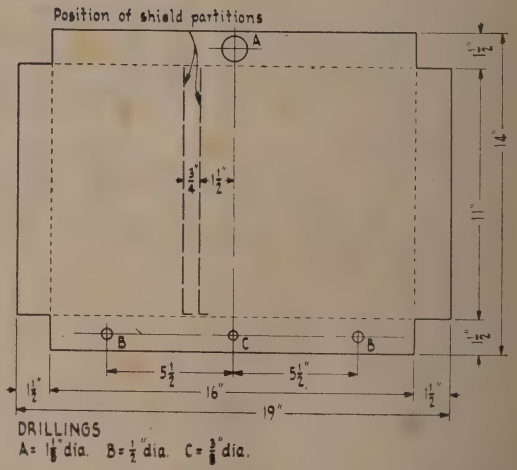


Fig. 4





Working drawings for the panel, chassis, and baffle shields.

and to require no neutralizing at all, even on the 10-metre band. This is somewhat of a tribute to the construction and low grid-plate capacity of the QQE06/40. Certainly, a good deal of trouble was taken to make the lay-out completely symmetrical, but here again this would not be done so easily were two separate valves used instead of the dual-unit QQE06/40. With the arrangement shown, it would have been an easy enough matter to arrange neutralizing wires to go through the shield partitions and run parallel to the plates of the valve had neutralization been necessary, but if the construction shown is carefully followed, no one should have trouble from instability.

The switches that can be seen in the front-panel view, Fig. 1, are a stand-by switch and a phone/C.W. switch. The former simply cuts the H.T. supply to the plate and screen of the final, while the latter short-circuits two contacts on the power plug at the back of the chassis. These contacts connect to the modulation transformer secondary, one to each end, so that the switch merely shorts out the secondary of the modulation transformer in the "C.W." position and removes the short on "Phone."

COIL SPECIFICATIONS

The coils are wound as follows. They can be constructed on insulating coil formers of good quality, if desired, but in the original they were all made self-supporting, except for strips of celluloid. The only exceptions were the 80 and 40-metre grid coils, which were close-wound and used celluloid sheet bent into a cylinder, as the former. Both grid and plate coils are wound in two equal sections so as to leave a large enough gap for the links to swing in and out without touching anywhere. The number refers to the circuit diagram which was given in last month's "Experimenter."

PLATE COILS (L_2)

Band.	Winding.
80m.	32 turns of 16 S.W.G. tinned wire, double-spaced, on a 3 in. diameter former. Gap between halves, 1 in.
40m.	22 turns of 16 S.W.G. tinned wire, double-spaced, on a 2 in. diameter former. Gap between halves, ⅞ in.
20m.	12 turns of 16 S.W.G. tinned wire on a 2 in. former, each half spaced to occupy 1 in. of winding space. Gap between halves, ¾ in.
10m.	10 turns of 16 S.W.G. tinned wire on a 1¼ in. former, each half spaced to occupy 1 in. of winding space. Gap between halves, ½ in.

(Continued on page 48.)

Output Links

80m. ..... 4 turns of 16 S.W.G. tinned wire, double-spaced, on a 3 in. former.

40m. ..... 3 turns of 16 S.W.G. tinned wire, double-spaced, on a 2 in. former.

20m. ..... 2 turns of 16 S.W.G. tinned wire, double-spaced, on a 2 in. former.

10m. ..... 2 turns of 16 S.W.G. tinned wire, double-spaced, on a 1¼ in. former.

GRID COILS (L_1)

80m. ..... 48 turns of 20 S.W.G. en. wire, close-wound, on a 1¼ in. former. Gap between halves, ⅜ in.

40m. ..... 30 turns of 20 S.W.G. en. wire, close-wound, on a 1¼ in. diameter former. Gap between halves, ⅜ in.

20m. ..... 18 turns of 16 S.W.G. tinned wire, on a 1¼ in. diameter former, each half spaced to occupy 1⅜ in. of winding space. Gap between halves, ⅜ in.

10m. ..... 10 turns of 16 S.W.G. tinned wire on a 1 in. diameter former, each half spaced to occupy ¾ in. of winding space. Gap between halves, ⅜ in.

Input Link

Note.—Only one input link is used for all four bands. It needs to be plugged in and out, however, to enable the grid coils to be changed.

All ..... 5 turns of 20 S.W.G. en. wire, double-spaced, on a 1¼ in. diameter former.

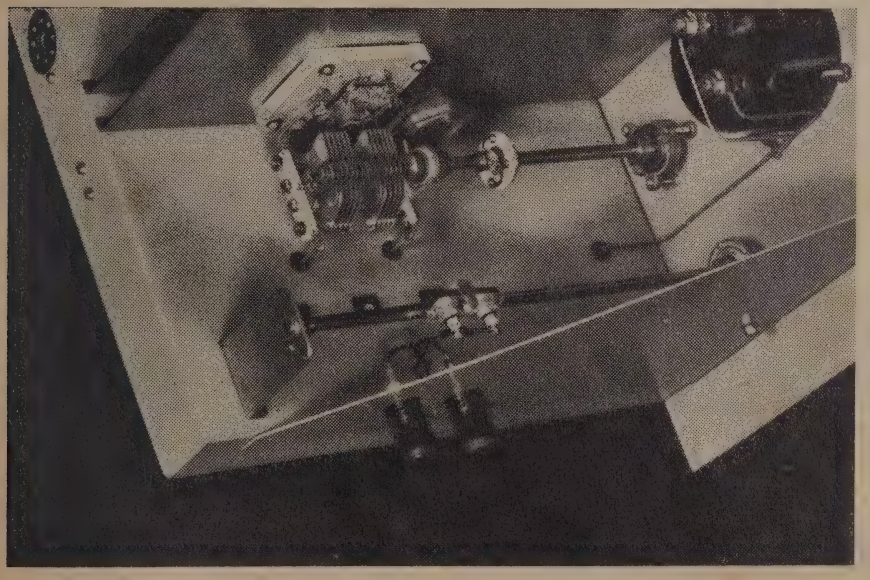


Fig. 5

TUNING UP THE FINAL

There will not be any need to say very much about tuning up the final, because we have found it to be the most easily-handled high-power stage we have come across. There will be no need to "cut and try" as far as the coils are concerned if they are made according to specifications, and all that needs to be done is to apply excitation, tune the grid circuit, and apply load and H.T. The whole business is just as easy as that. The only difficulty that seems at all likely to crop up is the possibility of parasitic oscillation. When we made our original bench "lash up" of the final, we had no trouble either with the stability or with spurious oscillation, but after the stage had been properly constructed, we found that, as the plate tank was tuned well out of resonance, peculiar jumps in plate and grid currents occurred. If this happens, it is a sure sign of parasitic oscillation, and, sure enough, when we turned off the excitation, there was a large grid current, together with about normal plate and screen currents. Checks showed that the trouble was at some very high frequency, as was expected, since low-frequency oscillation was rather unlikely in this particular circuit. All that was needed to cure the trouble was to insert small R.F. chokes in each grid lead, between the grid pins and the grid tank condenser, C_1. These chokes were wound on a 1-watt resistor as a former, and consisted of 30 turns of 24 S.W.G. D.C.C. wire. After this, no trouble of any sort was encountered, and the final behaved exactly "according to the book."

On no account must the plate and screen voltages be applied before the grid current has been tuned to resonance, unless cathode bias is used. In any case, it is best to tune up the grid circuit before applying plate and screen voltages. Also, it is inadvisable to work the stage unloaded except for very short periods, since the screen dissipation is likely to be exceeded. On the very short tests made without load on the amplifier, it was found that the plate current dipped right down to 15 ma. on all bands, so that under these conditions the plate and screen currents were approximately the same. It will be necessary, of course, to load the stage only lightly while the load circuit is to be tuned to frequency. When this has been done, the plate current having been set exactly on the dip beforehand, all that is needed to load the amplifier fully is to turn the output coupling link so as to mesh with the tank coil. The milliamps will go up until full power input is indicated on the plate meter, and far beyond, and once it is set to a plate current of 150 ma., it will be found that the dip is still there, if the plate tank is tuned through resonance, and occurs right at the point of maximum power output if the load is not reactive. If an aerial coupling unit is used (and this is strongly recommended), there will be no difficulty in presenting a resistive load to the final, even if there are standing waves on the line to the aerial. The presence of reactance in the load, as will happen when the output link is directly connected to feeders on which there remain standing waves, can be detected because of the fact that minimum plate current will not occur at the same spot on the plate tank condenser as maximum power output. If this occurs, the final plate tank should be tuned for maximum power output, and not for minimum plate current.

In any case, especially when the final is to be

(Concluded on page 48.)

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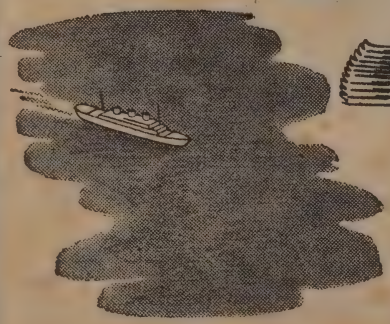

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PART II

CIRCUIT FOR TOP CUT

The fundamental circuit for top cut is given in Fig. 5 (a). By now the reader should be able to work out for himself how this acts, and how the addition of the variable resistor in series with C_4 gives control over the degree of cut obtained.

COMBINATION OF TOP LIFT AND CUT

Just as the circuits of Figs. 1 (b) and 2 (b) can be combined in one circuit to give bass boost or cut, depending on the setting of R_3, so it is possible to combine Figs. 4 (b) and 5 (b) to give top life or cut, and this combined circuit is shown in Fig. 6.

THE FINAL CIRCUIT

As with the circuit of Fig. 3, it is possible to use that of Fig. 6 separately, if one is interested only in compensating the top end of the scale. However, most often some sort of compensation is needed at both ends, so that the most useful circuit is one

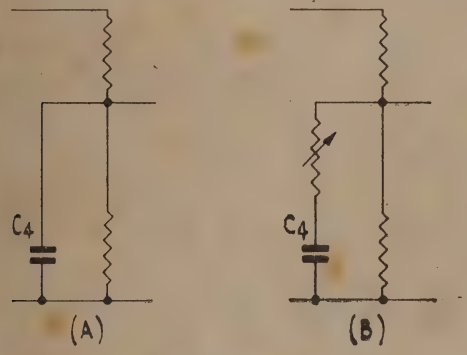

Fig. 5

which will combine all four functions. Such a circuit is that of Fig. 7. The various parts of this arrangement can be recognized from the individual circuits we have already discussed. The only thing about Fig. 1 that might not be immediately obvious is that, whereas each circuit (Fig. 3 and Fig. 6) has its own voltage divider, the combined circuit has only one—namely, R and R_1. It might be thought that this sandwiching of the two voltage divider chains might have some effect which would prevent the bass and treble circuits from functioning independently, but this is not so. R and R_1 on Fig. 7 act in exactly the same way as R_1 and R_2 on Fig. 6. The reason why the condensers C_2 and C_1 do not affect this action in any way is that their values are large, and both of them can be regarded as short circuits at high frequencies, where the top-cut-and-lift circuit has to work. Similarly, C_3 and C_4 have no practical effect on the low-frequency response, because of their position in the circuit and because of the small size of C_3.

A PRACTICAL CIRCUIT WITH VALUES

Most readers will have been waiting for a circuit, complete with values of resistors and condensers, which they can apply to their own amplifiers without further ado. Such a circuit is given in Fig. 8. It will be noticed that in order to apply the circuit of Fig. 7,

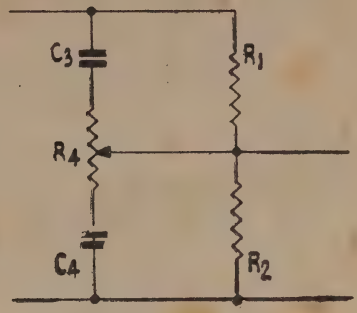

Fig. 6

it is used as a coupling network between two amplifier valves. The only additional component that appears, apart from the valves, is the load resistor of the first valve. The grid of the second is connected directly to the paralleled moving arms of the control potentiometers, and since there is a D.C. path to earth, there is no need for an additional coupling network to provide a grid return path for the second valve.

The 0.5 μf. blocking condenser, of course, is not part of the tone-control network either, and is there merely to prevent the D.C. voltage from the plate of the first valve from appearing in the grid circuit of the second. It is thus only a blocking condenser, and its value is larger than usual because of the low value of the resistors in the tone-control circuit. The

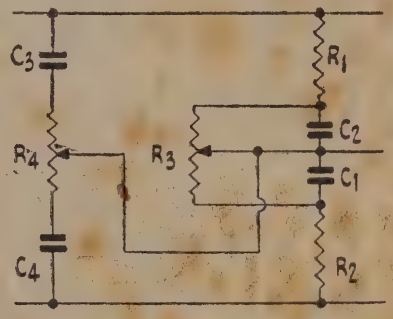

Fig. 7

values given in Fig. 8 are stated by James to give about 10 db. boost at 50 c/sec., 12 db. cut at the same frequency, and 10 db. boost at 6000 c/sec., and 16 db. cut at this frequency. Our own tests of the same circuit, however, have shown figures that are rather smaller than this. This is of little significance, though, because it is an easy matter to alter the values in the circuit, once it is known how it works, so as to get considerably more or less than these figures. In fact, the main reason why we have bothered to describe the circuit and its derivation from the basic ones, in so much detail, is that if the reader knows how it works, modification is easy, and the result can be predicted. Without this knowledge, however, altering such a circuit can only pro-

(Continued on page 48.)

duce confusion and, very probably, nothing like the desired result.

SOME POINTS WITH RESPECT TO THE VALVES

Those who are not very interested in the theoretical aspects of the circuit of Fig. 8, but only in its particular values, can skip the following part of the story if they so desire, but it should be carefully read by those who might wish to design their own networks, with different values of C and R. The points that we are about to discuss have been taken care of in the development of the circuit of Fig. 8, but any original network must also take them into account if the results are to be satisfactory.

The problem of designing a network with a certain frequency response, or combination of responses, as here, is one thing, but the application of that circuit, once designed, to a valve circuit is quite another. In other words, the valves themselves and their proper operation depend on those characteristics of the network that are not merely a matter of frequency response. The chief difficulty about such networks, when they come to be used between valves, is that they do not represent an input impedance that is at all constant. That is to say, the input impedance of the network depends very much on where the controls happen to be set. Worse than this, it can fall to quite a low value, so that if this is not remembered when the design is "on the board," as it were, there are likely to be disastrous effects.

It will have been noted that the valves shown in Fig. 8 are triodes. The second one can, if desired, be a pentode, but for best results the one whose plate

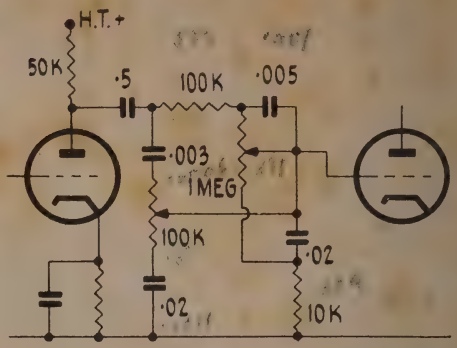

Fig. 8.—This circuit gives independent control of high and low frequencies with only two potentiometers to give bass boost or cut. It should be used to follow a triode amplifier, as early in the circuit as possible.

circuit feeds the network should be a triode. There are several reasons for this, but at the moment we will take them as read, and discuss the possible effects of the system on the first valve, which we will assume to be a triode. It is well known that the load resistor for a resistance-coupled triode should not be less than four to five times the plate resistance of the valve if voltage output and distortion are to be kept to reasonable figures. Thus, in an ordinary stage, it is quite safe to use a plate load resistor of, say, 50k., since the plate resistance of most low-impedance triodes that are used in this

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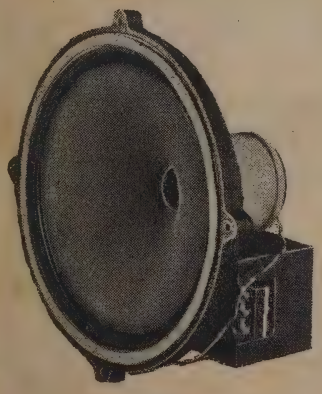
connection is in the region of 10,000 ohms. Now, let us examine the circuit of Fig. 3 in the light of the load imposed on the preceding valve, assuming the network to be coupled to the plate circuit in the same way as is Fig. 7, in the circuit of Fig. 8. The values we will take as being those used in Fig. 8. Thus, R_1 is 100k., R_2 is 10k., and R_3 is 1 meg. It will be remembered that at high frequencies the condensers can be regarded as short circuits, so that it is at high frequencies, too, that we can expect the network to have its smallest impedance and to cause trouble, if any. Thus, at high frequencies, the presence of the potentiometer can be disregarded, and the impedance of the whole circuit will virtually be the sum of R_1 and R_2. This is 110,000 ohms, and is in parallel with the plate load resistor, as far as providing a load for the valve is concerned. Thus, the actual A.C. plate load for the valve is 33,000 ohms. In the case of, say, a 6J5, or half of a 6SN7, this represents approximately 5 times the plate resistance, so that there should be no ill effects either on the distortion or on the voltage-handling capacity of the valve. However, if it was wanted to use a 6Q7 in front of the network, the values would be rather low, since the plate resistance of this type is approximately 30,000 ohms. This would mean that the 6Q7 would not be able to give anything like its normal maximum undistorted output voltage. As long as this was realized, and the valve was not expected to give its normal output voltage without distortion, no harm would necessarily arise. This brings out one very important point about these tone-compensation stages: **It is important to place them as early in the amplifier as possible.** The reason for this is almost self-evident, for the earlier the circuit is placed the smaller the signal voltage that the valve concerned is called upon to handle, and the less is the likelihood of distortion arising in the amplifier through improper load conditions in the stage before the compensating network.

We ourselves have stressed this point in many places in these pages; in fact, this has been done whenever the question of tone-compensation has arisen. In fact, if the network can be placed in front of the whole amplifier, so much the better from this point of view. It will be remembered by our older readers that in one amplifier designed by us, a two-stage response-compensating network was included as an integral part of the design, and that it was placed right at the input to the amplifier. This is the reason for so doing.

Apart from using a valve before the network which has a low plate resistance (and this will usually mean one with a low amplification factor also), it is possible to do much when designing the network to see that load impedance trouble does not occur. For example, suppose it is desired to use the circuit of Fig. 8 with a preceding valve that has a plate resistance of 25,000 ohms. There is quite an easy way out of the difficulty, and that is to take a suitable factor and multiply by it the value of all resistors in the network. Then, DIVIDE the values of all the condensers by the same factor, and we

(Continued on page 48.)

The TANNOY High-fidelity Loudspeaker



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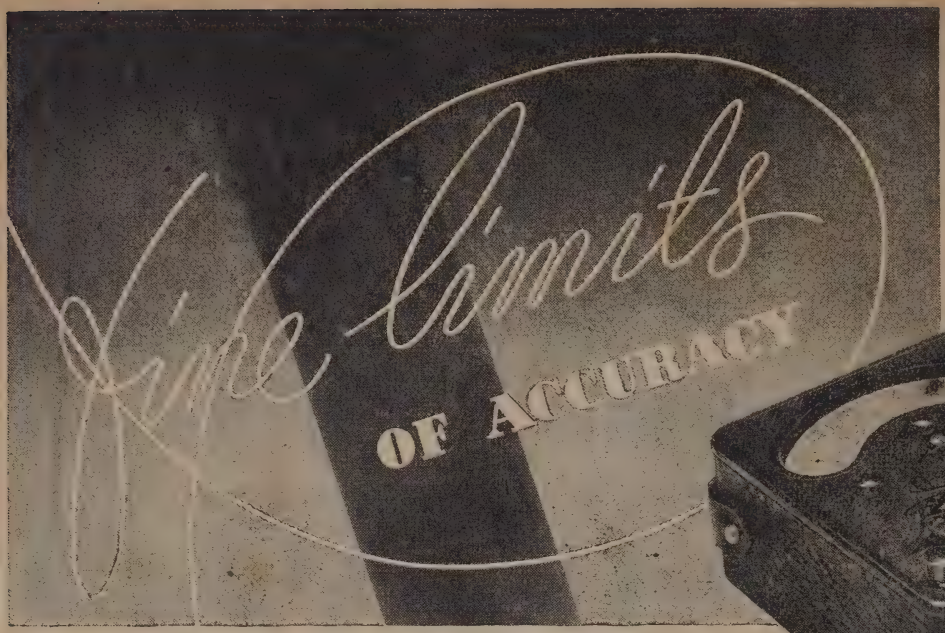

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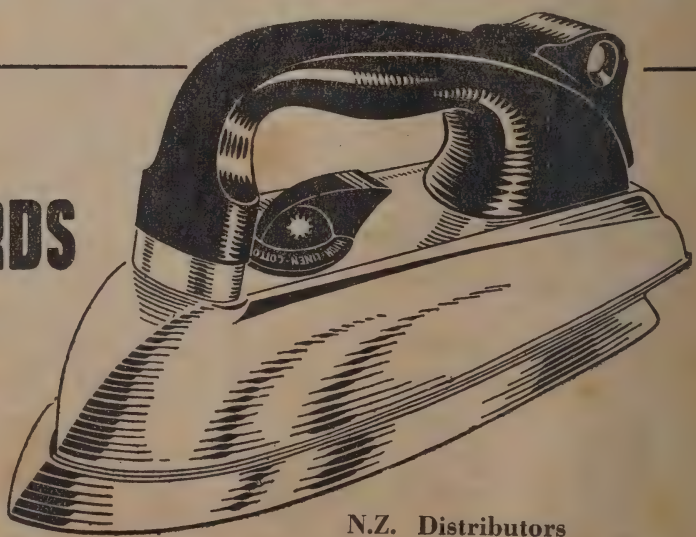

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ELECTRONIC TIME MEASUREMENTS

"Electronic Time Measurements," edited by Britton Chance, Robert I. Hulsizer, Edward F. MacNichol, jun., and Frederick C. Williams. (McGraw-Hill Book Company, Incorporated.)

This book is Volume 20 in the Radiation Laboratory Series of the Massachusetts Institute of Technology covering the field of radar development during the last war; but it is an especially valuable volume because, like Waveforms No. 19, the subject-matter covers both British and American developments alike. In this connection, many readers will have little difficulty in recognizing the import of the last-named editor, Professor F. C. Williams, the circuit wizard of the British Telecommunications Research Establishment. This collaboration between the two countries is specially valuable in this portion of the wide range of radar developments, for it was in the basic scientific ingenuity that the British excelled, just as did their American counterparts in the practical, engineered developments of these inventions. It is indeed almost true to say that this book covers more British than American techniques and equipments. For those few who are unfamiliar with this Radiation Laboratory Series, let it be said at once that the title of this volume would more correctly be given as "Electronic Measurement of Short-time Intervals," for he must look elsewhere who is in search of a treatise on the application of modern electronic techniques, such as super-accurate quartz crystal clocks, to the fundamental measurement of time. This book is concerned almost entirely with the accurate measurement of intervals of time; of the order of micro- and milli-seconds such as were encountered in the development of war-time radar. Even the more detailed description of circuits for producing basic fixed-time indices, such as crystal-controlled valve oscillators, is to be found in Volume 19 of the series.

The volume under review is the logical development of the practical application of the basic circuit techniques described in Volume 19, and the maximum value of Volume 20 is obtained only if Volume 19 is available for reference.

The application of the basic techniques to the requirements of war-time radar, for accurate distance-finding and data transmitting calls for an appreciation of the particular radar systems, and this requirement has been admirably met throughout both by an introductory survey of basic operational techniques used in various radar systems and by brief but adequate descriptions of the purposes for which specific applications were developed. Only a knowledge of the extremely wide and diverse range of equipments covered in this book could lead to an appreciation of the excellent editing in this respect. A strong bias is shown for army and air force equipments, and little mention is made of that used by the navies.

In brief, the book makes a survey of circuit techniques and methods used in pulse time measurement, including the generation of fixed and movable timing markers and their application to manual and automatic measurement of time intervals.

In more detail, time modulation and demodulation circuits are covered; while the frequency division of pulse trains, as distinct from counting, is treated in considerable detail with numerous circuit examples. The many single and multi-wave variations of the basic Miller circuit for producing variable single-scale time indices are described, as also is the use of supersonic delay tanks and variable frequency oscillators for the same purpose. The production of variable time indices from multiple scale modulation of pulses generated by crystal or L/C oscillators is covered by practical applications of the time modulation circuits described in the earlier chapters.

The chapters on manual and automatic measurement of time intervals, which cover almost half the book, are profuse with illustrations and descriptions of war-time equipment in which the essential facility of accurate time measurement was used to fulfil so many and varied operational requirements demanded of war-time radar. The descriptions are written from an engineering rather than from a purely scientific viewpoint, the mathematics being used almost entirely for developing the principle of operation of the particular application. Manual and automatic methods of range measurement, of tracking, of following, of target selection, etc., are fully described with reference to such systems and equipment as GEE, LORAN, OBOE, SHORAN, C.M.H., S.C.R. 584, etc.

One particular application of the use of time measurement—namely, the use of data transmission such as relaying P.P.I. displays, is given a separate chapter, and four methods of performing this difficult task as described in some detail. Now that moving-target indication or permanent-echo suppression has become a standard fitting to so many post-war radar systems, the concluding chapters are specially valuable. Even though the work described here presumably covers up to the 1945–46 period only, it provides an excellent basis for the understanding of current practical solutions to the problems involved in this feature, describing as it does those used in the initial stages and the fundamental approaches to its requirements.

The book is exceptionally well produced and provided with a rather brief but very useful index, together with a valuable glossary of war-time radar circuit jargon. The many circuits printed are clear, well drawn, and complete with component values (usually excluding inductances), and valve types. For American equipment this is sufficient, but since British data have been drawn in the main from official documents, the valve numbers quoted are those used in the Services. To the old radar fraternity who saw service in the United Kingdom, this would not present much difficulty, but to young engineers who would not have that almost family affection for the V.R.91 or theV.R.65, some form of cross reference is essential, particularly in the case of such special "time circuit" valves as the V.R.116.

In a technical publication which must be almost unsurpassed in its field, it must be somewhat reluctantly commented that even more than in most of this series, it tends to suffer from occasional discontinuities and variations in methods of approach. Perhaps this is as much due to the exceptionally wide range of specialized applications covered as to the number of contributing authors. W. S. JOYNER.

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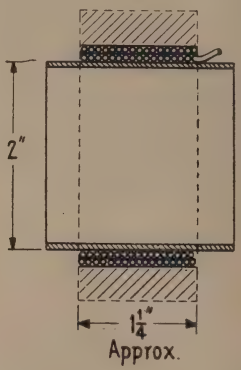
DESIGN SHEET NO. 9

AIR-CORED CHOKES FOR SPEAKER-DIVIDING NETWORKS

Elsewhere in this issue of "Radio and Electronics" will be found a comprehensive article on speaker-dividing networks, which tells how a suitable network may be designed to suit a given combination of speakers and a given cross-over frequency. Formulae are given, related to one particular circuit for the network, from which the required choke inductances may be found. The present chart shows how these inductors, which must be air-cored, may be wound to the values of inductance that may be required.

Fig. 1 has been prepared to show the type of winding that the chart refers to, and if the chart is to be at all accurate, the wire size and the winding dimensions must be strictly followed. If this is done, all that is necessary is to refer to the chart to find the number of turns that must be put on to give a coil of the required inductance.



Former, 2 in. diameter; wire, 20 S.W.G. enamelled; winding, 30 turns per layer (close wound), with two thicknesses of good-quality writing paper between each two layers of wire.

To take an example that was worked out in the article referred to above, we find that for a cross-over frequency of 1250 c/sec. and a speaker voice-coil impedance of 15 ohms, the required inductance for the chokes is 2.8 millihenries. Referring this to the curve, we find that 250 turns are required. Since Fig. 1 tells us that each layer must have 30 turns in it, there will be eight full layers and ten turns on the ninth layer.

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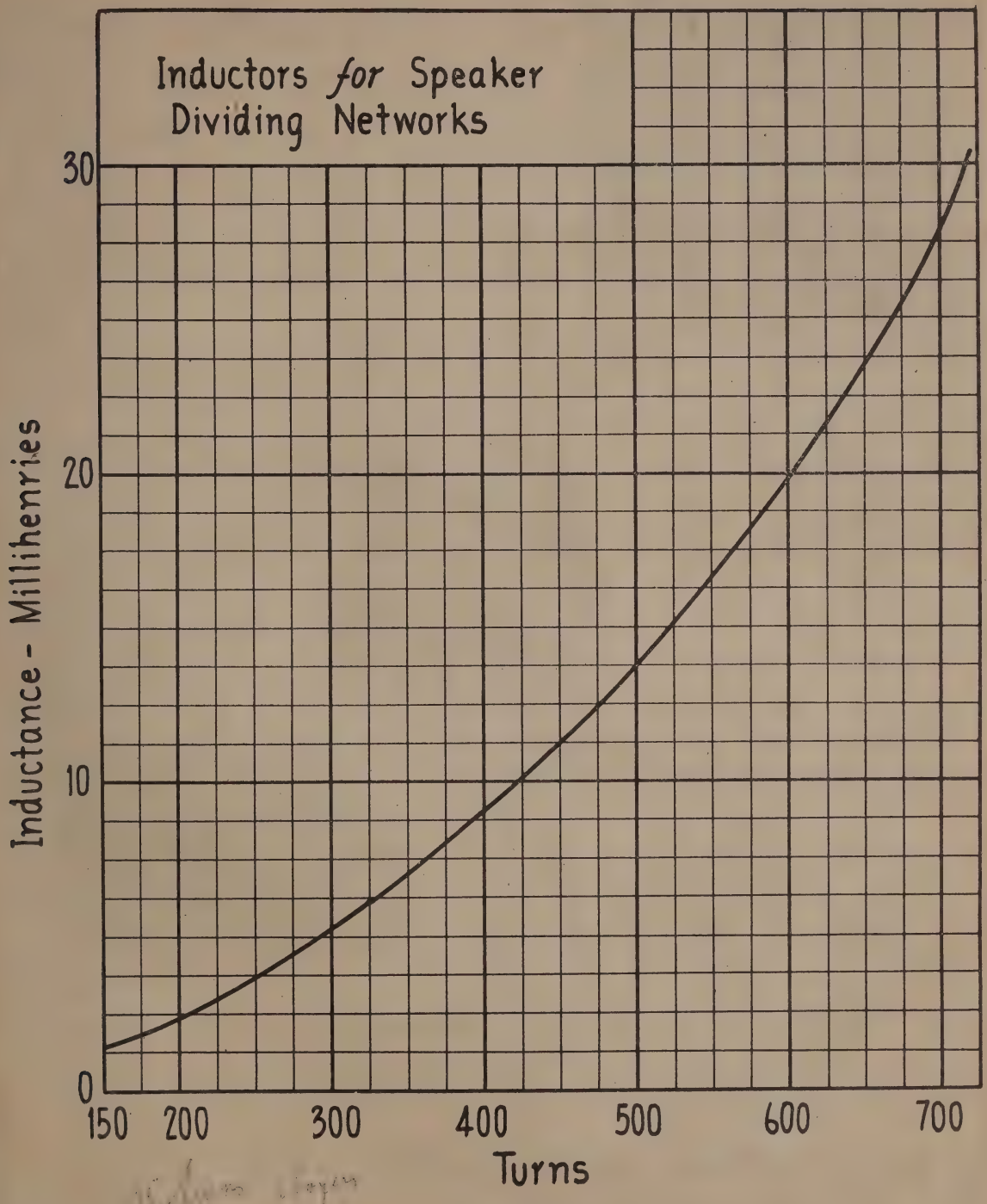
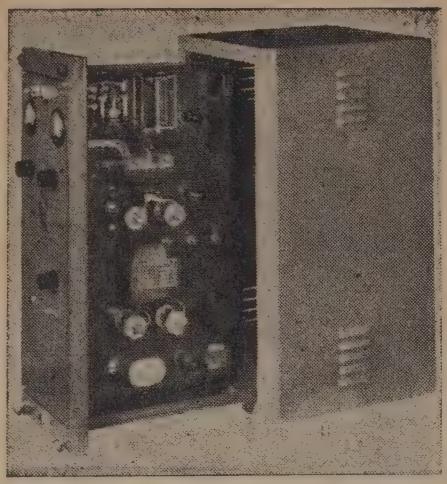

Inductors for Speaker Dividing Networks
Inductance - Millihenries
30
20
10
0
150
200
300
400
500
600
700
Turns



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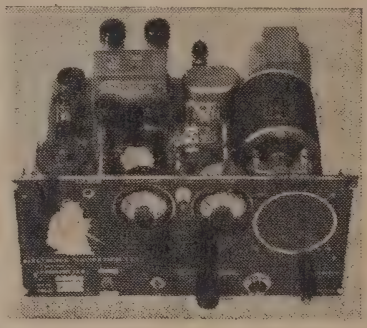

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QUESTIONS AND ANSWERS

(Continued from page 9.)

tions, and the detuning effect on the mixer circuit to zero.

It should be mentioned that, with the circuit of the adaptor as given, it is possible to over-swing the reactance modulator so that the frequency excursions on either side of the centre frequency are by no means linear, and that this, combined with an over-driven deflection amplifier, can produce some very weird effects. Those described by W.T.S. are in all probability due to a combination of these causes.

PRESENTATION OF VALVE DATA

H.A.S., of Hastings, writes to us saying that he has read with interest our dissertation on the design of a car-radio, which appeared in the "Questions and Answers" page in last November's issue. He intends to build a circuit following our suggestions but using the low-noise 6J6 mixer circuit which we have since published, instead of the infinite impedance mixer that was originally recommended. He says: "Instead of a 6J6 I will use an ECC91, but I notice that the makers recommend an H.T. voltage of only 100 volts, whereas the set will have 250. I am wondering if this will not be a source of trouble."

In the first place, it is useful to know that the 6J6 and the ECC91 are direct electrical and mechanical equivalents. Thus, any circuit designed for the former can be used simply by plugging in the latter, or vice versa.

Secondly, on looking up the page of data on the ECC91, as given by its makers, we find that our

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correspondent is correct, up to a point. That is to say, under the heading of "Characteristics," there is a list which gives the amplification factor, mutual conductance, and plate resistance. This list is headed by the information that the plate voltage is 100, and also states that the cathode bias resistor was 100 ohms. Now this does not mean that the maximum plate voltage is 100 volts, or even that the conditions quoted are typical operating conditions, but simply that the figures for R_p, G_m, and μ were measured under these conditions. This practice is followed as a guide to users, because all three of these important qualities vary with plate voltage and plate current. Lower on the page are given maximum ratings, which include one of 300 for plate voltage. Thus, the suggested operating conditions are quite satisfactory.

The same practice is often followed by English and Continental valve manufacturers in quoting the valve constants. It is good practice, too, because often valve data does not specify the conditions under which the characteristics were obtained, thus making it much harder for the user to say whether a certain sample is up to scratch or not.

THE "JUNIOR COMMUNICATIONS RECEIVER"

A correspondent writes that he has built the above receiver, and has it performing excellently on 80m., but that he cannot get it to tune down to the 10-metre band. He states that the coils for this band have been constructed according to specifications, but that no setting of the various condensers gives him tuning to the 10m. band. He asks if we can help by telling him what is the matter.

Now, we have included this question in this month's "Questions and Answers" because it is an excellent example of the kind of question we do not like to receive. Not because it tells of someone having trouble with one of our circuits—we frequently do ourselves—but because it gives insufficient data on which to frame an answer.

The letter states that the set will receive the Australian shortwave broadcast station on 11 mc/sec., but fails to indicate whether this is with the offending coils in place or on the coils for the next lowest band, which is where it ought to come. A set of this nature is capable of receiving images quite well, if the first detector tuning is turned to the wrong spot. Further, there is no evidence to show that the set will not tune to the 10-metre band. This does not mean that we do not believe in our correspondent's veracity, but simply that on a band like this, especially in the middle of winter, there is no guarantee that he was listening at a time when the band was open. Also he does not state whether his pronouncement was made after using a signal generator on 28 mc/sec., and attempting to receive that. It can be seen that we have only a bare statement which may or may not be a mistaken one on which to work. Even if we assume the statement to be correct, there is not enough information in the letter to tell us by how much the set misses tuning to the required frequency. In a case like this, all we can do is to recommend that the set be checked with a signal generator to see just what the highest receivable frequency is. It is possible, of course, that, due to unavoidable differences in the construction of the wiring, as between one set and another, this

(Concluded on page 47.)

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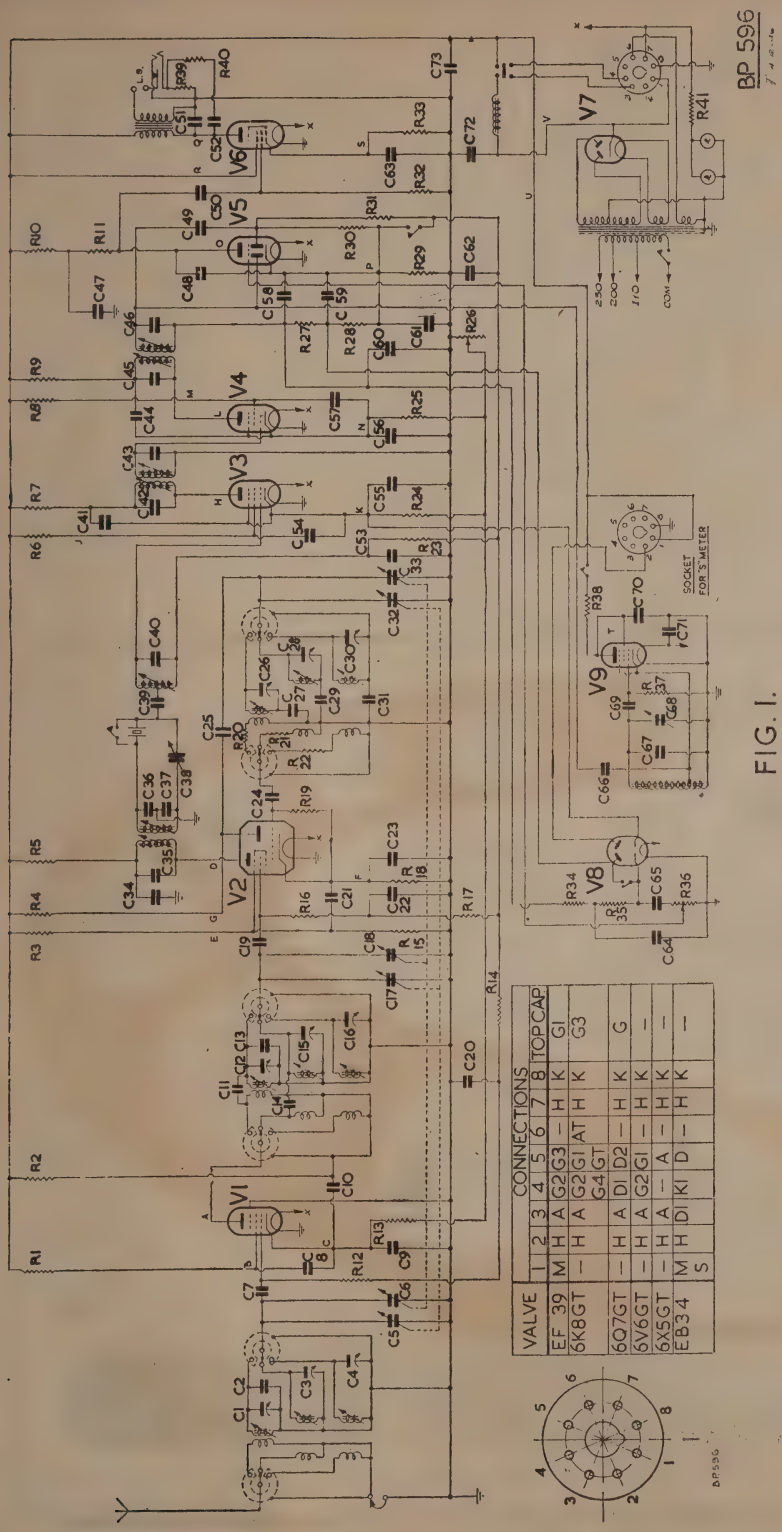

FIG. 1.

VALVE	CONNECTIONS 1	2	3	4	5	6	7	8	TOP CAP
EF 39	M	H	A	G2	G3	—	H	K	G1
6K8GT	—	H	A	G2	G1	AT	H	K	G3
				G4	GT				
6Q7GT	—	H	A	D1	D2	—	H	K	G
6V6GT	—	H	A	G2	G1	—	H	K	—
6X5GT	—	H	A	—	A	—	H	K	—
EB34	M	H	D	K	D	—	H	K	—
	S								

FOR THE SERVICEMAN

This month's circuit features the Eddystone Model 640, which has been sold in quite large numbers in this country.

COMPONENT VALUES

Resistors

R1, 0.1 meg. ½ watt.
R2, 4700 or 5000 ohms ½ watt.
R3, 15,000 ohms 1 watt.
R4, 27,000 or 30,000 ohms, 1 watt.
R5, 4700 or 5000 ohms ½ watt.
R6, 0.1 meg. ½ watt.
R7, 4700 or 5000 ohms ½ watt
R8, 1 meg. ½ watt.
R9, 4700 or 5000 ohms ½ watt.
R10, 27,000 or 30,000 ohms, ½ watt.
R11, 0.27 or 0.25 meg. ½ watt.
R12, 0.47 or 0.5 meg. ½ watt.
R13, 400 ohms ½ watt.
R14, 0.47 or 0.5 meg. ½ watt.
R15, 22,000 or 25,000 ohms 1 watt.
R16, 0.47 or 0.5 meg. ½ watt.
R17, 0.47 or 0.5 meg. ½ watt.
R18, 330 ohms, ½ watt.
R19, 47,000 or 50,000 ohms ½ watt.
R20, 12 ohms
R21, 100 ohms ½ watt.
R22, 560 or 500 ohms ½ watt.
R23, 47,000 or 50,000 ohms ½ watt.
R24, 400 ohms ½ watt
R25, 330 or 300 ohms ½ watt.
R26, 10,000 ohms pot.
R27, 0.1 meg. ½ watt.
R28, 0.47 or 0.5 meg. ½ watt.
R29, 4700 or 5000 ohms ½ watt.
R30, 0.47 or 0.5 meg. ½ watt.
R31, 0.47 or 0.5 meg. ½ watt.
R32, 0.27 or 0.25 meg. ½ watt.
R33, 270 ohms 1 watt.
R34, 1.0 meg. ½ watt.
R35, 2.2 meg. ½ watt.
R36, 0.5 meg. pot.
R37, 47,000 or 50,000 ohms ½ watt.
R38, 22,000 or 25,000 ohms ½ watt.
R39, 3300 ohms ½ watt.
R40, 33,000 ohms ½ watt.
R41, 2.6 ohms approx.

Condensers

C1, 3—20 pf. air trimmers.
C2, 20 pf. ceramic cartridge.
C3, 3—20 pf. air trimmers.
C4, 3—20 pf. air trimmers.
C5, 12—366.5 p.f. bandset, 3 gang.
C6, 9—46.2 pf. bandspread, 3 gang.
C7, 100 pf. silvered mica
C8, 0.01 μf. tubular paper.
C9, 0.01 μf. tubular paper.
C10, 0.01 μf. tubular paper.
C11, 20 pf. ceramic cartridge.

C12, 3—20 pf. air trimmers.
C13, 10 pf. ceramic cartridge.
C14, 6 p.f. ceramic cartridge.
C15, 3—20 pf. air trimmers.
C16, 3—20 pf. air trimmers.
C17, 12—366.5 pf. bandset, 3 gang.
C18, 9—46.2 bandspread, 3 gang.
C19, 100 pf. silvered mica.
C20, 0.01 μf. tubular paper.
C21, 0.01 μf. tubular paper.
C22, 0.01 μf. tubular paper.
C23, 0.01 μf. tubular paper.
C24, 100 pf. silvered mica.
C25, 100 pf. silvered mica.
C26, 3—20 pf. ceramic trimmer.
C27, 2100 pf. silvered mica.
C28, 3—20 pf. ceramic trimmer.
C29, 950 pf. silvered mica.
C30, 3—20 pf. ceramic trimmer.
C31, 380 pf. silvered mica.
C32, 12—366.5 pf. bandset, 3 gang.
C33, 9—46.2 pf. bandspread, 3 gang.
C34, 0.01 μf. tubular paper.
C35, 200 pf. silvered mica.
C36, 400 pf. silvered mica.
C37, 400 pf. silvered mica.
C38, crystal phasing condenser.
C39, 20 pf. ceramic cartridge.
C40, 200 pf. silvered mica.
C41, 0.01 μf. tubular paper.
C42, 200 pf. silvered mica.
C43, 200 pf. silvered mica.
C44, 0.01 μf. tubular paper.
C45, 200 pf. silvered mica.
C46, 200 pf. silvered mica.
C48, 8 μf. tub. electrolytic.
C48, 0.0005 μf. moulded mica.
C49, 40 pf. ceramic cartridge.
C50, 0.01 μf. moulded mica.
C51, 0.002 μf. moulded mica.
C52, 0.01 μf. tubular paper.
C53, 0.01 μf. tubular paper.
C54, 0.01 μf. tubular paper.
C55, 0.01 μf. tubular paper.
C56, 0.01 μf. tubular paper.
C57, 0.01 μf. tubular paper.
C58, 40 pf. ceramic cartridge.
C59, 40 pf. ceramic cartridge.
C60, 0.0005 μf. moulded mica.
C61, 25 μf. 25v. tub. electrolytic.
C62, 0.01 μf. tubular paper.
C63, 25 μf. 25v. tub. electrolytic.
C64, 0.1 μf. tubular paper.
C65, 0.01 μf. tubular paper.
C66, 3 pf. ceramic cartridge.
C67, 200 pf. silvered mica.
C68, B.F.O. pitch control.
C69, 100 pf. silvered mica.
C70, 0.01 μf. tubular paper.
C71, 0.01 μf. tubular paper.
C72, 8 μf. tub. electrolytic.
C73, 16 μf. tub. electrolytic.

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2-METRE CONVERTER

(Continued from page 8.)

loosening the lock-nuts between the box and the chassis, but the box should not be at all floppy after it has been mounted. The play allowed was just enough to make it possible to fit the dial without using a flexible coupling. The box is thus able to be mounted only an inch from the front panel. Underneath the chassis are found the power supply components, apart from the transformer, and the whole of the mixer circuit.

THE MIXER WIRING

In the underneath view, the mixer socket is almost obscured by the small condenser mounted over it, but some of it can be seen, between the leads from the aerial terminals. The split-stator tuning condenser is right beside the mixer socket, and, although it is screwed down to the chassis, a thick wire is taken from the central wipers to an earth point just between the socket and the condenser. The line-tuned circuit can be seen very clearly in the photograph. The condenser, or high ends, can be seen soldered direct to the stator connecting lugs, after having been bent slightly outwards so as to allow for the slightly closer spacing of the line compared with the lugs themselves. At the bend is a small perspex spacer, to give rigidity, and another will be seen at the upper end, which is the closed or short-circuited end of the line. The shorting bar is made in the form of a "T." The cross-piece of this has holes into which the ends of the line are soldered, and the vertical piece is firmly soldered to the frame of the condenser where the wipers are attached to it. By means of bending the line over in this way, not only is the space taken by the line halved, but also the earths on the whole mixer circuit are brought to the one point, which is very good practice electrically.

The small smoothing choke and the two smoothing condensers are mounted on the back of the chassis.

The output tuned circuit, on 14 mc/sec., can be seen in the left-hand front corner of the photograph. The coil is a standard one such as is used in the shortwave range of dual-wave coil units; the primary is not needed, so the winding is removed and the lugs used as tie-points for the fixed condensers. The tuning is done with the Philips trimmer mounted on top of the coil. This is done by bending the bottom connecting pin at right-angles and soldering it to one of the coil connecting lugs near the top of the former. The output socket is just behind the tuned circuit on the back of the chassis.

The mixer tuning is operated by an extension shaft, through the front panel, and a flexible coupling to the condenser shaft.

MODIFICATIONS TO THE CIRCUIT

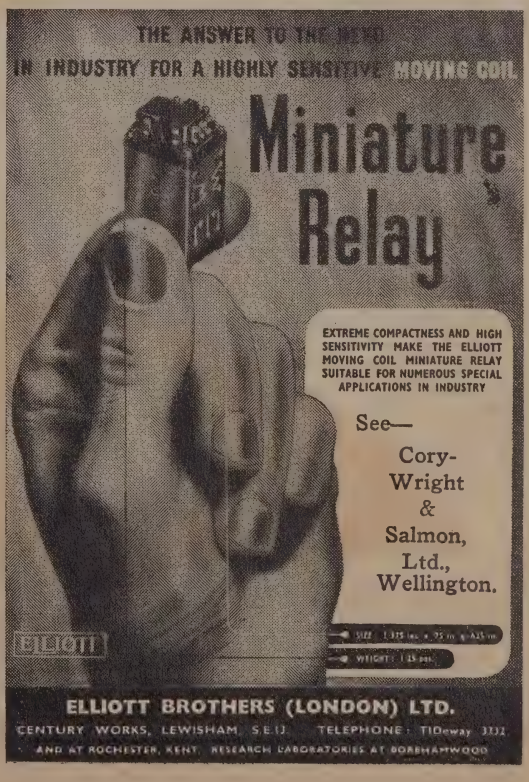
Since the original experimental work was done on this converter, two slight modifications have been found to improve the mixer performance. One is to bypass the cathode resistor with a 50 $\mu\mu$f. mica condenser. This in turn makes it possible to dispense with the grid-stopper which was previously found necessary in order to prevent cathode-follower oscillation of the mixer circuit. The damping on the tuned circuit is much reduced, with a great improvement in selectivity, and therefore in image response. No attempt has been made to bandspread the mixer tuning, as this was not considered worth the trouble involved.

As a result of these modifications, it was found that, as expected, the length of the line had to be considerably reduced. The reason is, of course, that bypassing the cathode resistor increases the input capacity of the mixer's grid circuit. The line shown in the photograph is the modified one. It is made of two pieces of 5/32 in. brass rod, spaced $\frac{1}{2}$ in. between centres. These proportions are those which give greatest Q for a two-wire line, and were used so that the selectivity and image response would be as good as possible.

The selectivity of the modified input circuit is so great that the frequency range covered by the circuit is enough to cause complete loss of all signals if the tuning control is far from the correct position. This does not make for difficult operation, however, since the correct place is easily found by tuning the mixer, on the absence of a signal, for greatest noise. If no ignition noise is available, some artificial noise from a buzzer placed some distance away from the converter will do as an artificial broad-band signal, and will enable the tuning of the mixer to be found very easily. Once found, tuning over the band with the oscillator will be found to require definite but slight adjustment to the mixer tuning.

The aerial coupling hairpin is almost hidden in the photograph, as it is under the top part of the line. The aerial terminals are one on either side of the T-shaped shorting bar, and the wire of the hairpin straddles the vertical portion of the bar. The spacing of the hairpin is not critical, and about $\frac{1}{8}$ in. from the upper part of the line. Needless to say, the hairpin is coupled to the short-circuited end of the line, and not to the "hot" end.

(Continued on page 46.)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OUR GOSSIP COLUMN

H.M.V. Retailers, Ltd., Wellington, are at present in the throes of alterations to their showrooms, one of the main features being the provision of ample room for the comfortable selection of and service of recordings. A "record bar" of a circular design, complete with a full display of the newest records,

is the latest innovation. In the words of Mr. H. R. Lewis, H.M.V. retail sales manager, this "bar" provides every service but drinks. The photograph shown here displays a portion of the ample showroom, where the new "bar" will cover the space now used for floor display.

* * *

Mr. G. K. Herring, general sales manager of Eveready (Aust.) Pty., Ltd., was a recent visitor to New Zealand. "Bob," as he is known to the Australian trade, travels so much by plane in Australia that he took the opportunity of crossing the Tasman both ways by the s.s. "Monowai," and recommends this method of travel as a real rest cure. Mr. Herring's visit was of short duration, but he was able to contact many Eveready distributors and retailers, summarizing his visit by saying, "It's a great country, and I must come over more often."

Incidentally, many requests have been received already for copies of the book Bob proposed writing, "All About New Zealand"—and this after a two-weeks visit!

Another overseas visitor to National Carbon Pty., Ltd., was Mr. O. R. Armstrong, secretary of Eveready (Aust.) Pty., Ltd., who broke his return trip from America to spend a few days at the Wellington plant. During these few days, Messrs. R. D. Greenwood and O. R. Armstrong really got down to business. Unfortunately, work prevented Mr. Armstrong from seeing much of New Zealand, but here again it is a case of "I must come again."

* * *

Our congratulations go to Stan Shea, of Tele-Communications, Ltd., who has just attained "fatherhood," being now the proud parent of a fair daughter. Now for some overtime on that washing machine, Stan!

It is strange how often Wellingtonians complain of Auckland's weather. Dud Billing says that the last trip was even worse than several others in this respect, for the cold was intense, and, in spite of Aucklanders' protests that this recent spell was unusual, Dud maintains that this has been his reception on every occasion on which he has visited Auckland. Visiting the Queen City on Radio Federation business, Dud seized every opportunity to contact local manufacturers, including Radio (1936), Ltd., and Dominion Radio, Ltd. Between Federation discussions he met Jim Eckford, of S.O.S., and managed to spend part of a day with Dave Craig on Courtenay and Exelrad matters.

* * *

When passing Bob Horribin's place at Northland, a member of the "Radio and Electronics" staff was prompted to remark on the ornamentation attached to the highest point of his premises. Bob boasts of having had wonderful reception ever since he installed the latest English type of anti-interference aerial. Business, says Bob, that veteran of radio, is very good. In fact, he was just on the point of departing for a distant suburb to collect a large quantity of material for servicing.

* * *

The new South Island representative for Russell Import Co., Ltd., is Brian McSherry, who has been in the thick of the radio industry ever since first commencing business. Until fairly recently he was with Lockyers, Ltd., of Napier, before moving to the South Island to join the Direct Supply Co., Ltd., of Christchurch.

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TRADE WINDS

The Annual Branch Managers' Conference of Philips Electrical Industries of New Zealand, Ltd., was held at Wellington headquarters during the first week in July. As during the year the new Wellington Sales and Service Branch has been established, this was the first occasion on which the four main centres have been represented.

Recently arrived in New Zealand is John H. Brookes, as a delegate from Philips Overseas Concern Management. Mr. Brookes was delighted to have arrived in time to participate in the conference, at which plans were laid to make available to New Zealand industry those electronic and scientific products which are in the course of development and those now in production but not hitherto available to many of the overseas countries.

Mr. Brookes was able to give the conference a stirring account of the tremendous efforts made in the rebuilding and re-equipping of the damaged Eindhoven works, which were partially stripped by the Germans. Equally entrancing was the story of the retraining of the personnel, and as a result, said Mr. Brookes, the output of the Philips concern had now quantitatively reached 40 per cent. higher than the pre-war peak. Qualitatively, he added, the products were never better. As to the variety of the articles now being made, these consisted of a series of entirely new scientific developments, new materials, and new processes, which were bound in the near future to ameliorate the lot of city and rural dweller alike.

All of these discoveries and inventions, emphasized Mr. Brookes, were automatically made available to the Philips factories in New Zealand, and, equally important, the necessary know-how was furnished to enable the New Zealand production to reach the same high standard as those overseas.

Mr. Brookes brought a most heartening message from the technical experts of the world-renowned Philips laboratories. He said they were delighted with the real progress made in Philips New Zealand factories and the high quality achieved, and he was glad to be able to pay this tribute to the factory management, staff, and employees of the New Zealand works.

* * *

Radio Repairs, Ltd., Auckland, announce that they have been appointed the sole New Zealand agents for J. H. Brierley (Gramophones and Recordings), Ltd., of Liverpool, England, and advise that stocks of the Brierley pick-ups will be available shortly.

* * *

National Electrical and Engineering Co., Ltd., has announced that the new "NEECO" lighting handbook will be available shortly. We have also heard that this firm has been appointed agents for Burgess Products Co., Ltd., Hinckley, England.

* * *

Johns, Ltd., of Auckland, has recently released its catalogue, List No. 5–49. It is one of the most comprehensive post-war radio catalogues yet released in New Zealand, covering 76 pages of small but legible litho print, and profusely illustrated. The reader is introduced once again to the wide range of components and complete equipment handled by this progressive Auckland firm. To those of recent association with the radio industry, the introductory part of this catalogue will be read with particular interest, as it tells of Johns' start in business away back in those experimental days of 1920. Old associates will be reminded of those days when broadcasting proper was not then in being, and of the vision and courage of Vic and Clive Johns in preparing, with a receiver service to listeners, for the first of the broadcasts. After 29 years, it is easy to accept the present-day amenities and joys of radio, and in the hustle and bustle of today's living, perhaps excusable for that reason only. However, this is an opportunity for "Radio and Electronics" to congratulate Johns, Ltd., on the production of a fine catalogue and on the fine achievement of the firm and its present popularity in the New Zealand radio industry.

WHAT OF RADIO SALES?

Reports seem to be conflicting as to whether sales are good, better, or indifferent. "Radio and Electronics" therefore made some inquiries, and summarize hereunder their findings.

Reports to hand show the trend of sales for the period to be generally better than for some years. One wholesaler advised that, for June, he had reached a winter sales figure not usually reached until September.

A large retail outlet stated that the ordinary domestic receiver sales were not particularly bright, but there were good sales to the discriminating purchaser. To those who desired full musical value, radiograms in fully styled cabinets were reaching peak sales.

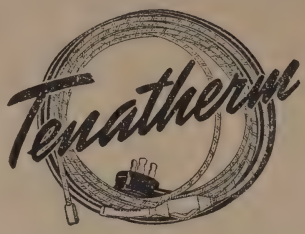
Sales of portables appear to remain steady, and it can be assumed that these, both indoor and outdoor models, are well established as an all-year-round seller, and can no longer be regarded as belonging to the holiday sales category only.

The demand for car radios is greater than the supply—perhaps because of the absorbing interest of the populace as a whole in current events, not the least of which are the fates of our respective football and cricket teams.

* * *

H.M.V. Sales and Service, Cuba Street, Wellington, has been appointed the sole Wellington agent for Sonophone inter-com. systems of S. D. Mandeno & Co., Ltd., Auckland.

(Continued on page 47.)



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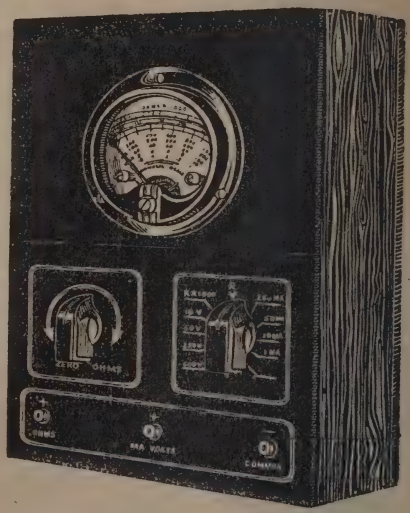
The circuit is built around a 3 in. 0.1 ma. 100 ohm internal resistance, Palec Meter fitted with an easily read Universal scale.

The complete unit is housed in a stained wooden cabinet measuring 9 in. x 7 in. x 3 in.



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A Practical Beginners' Course

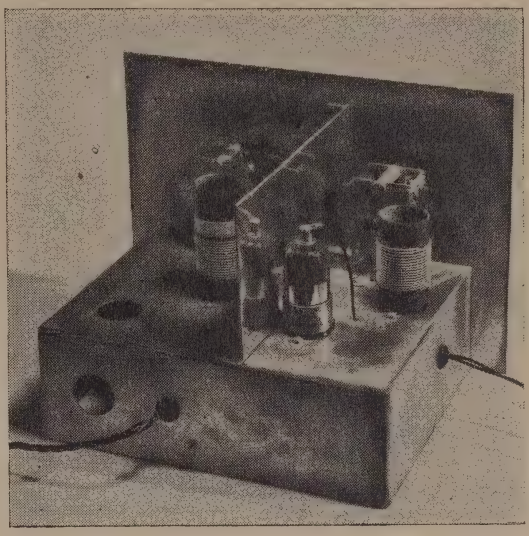
PART 34: TUNED R.F. STAGES IN COMPLETE RECEIVERS

In the last instalment of the course, we described how to build a stage of tuned radio frequency amplification separately, on its own base-board, in such a way as to allow it to work in conjunction with a crystal set or one-valve regenerative set. At broadcast frequencies, this scheme can be made to work quite well, but it is not the most convenient possible arrangement, since a set should be built in one piece rather than in two or more sections. It is quite possible that some readers may have had difficulty in making the separate R.F. stage perform properly on account of instability. That is to say, that, in spite of having used a screen-grid valve, a stage built as described is not necessarily stable. This might come as something of a shock to readers who have been following the Course, since we pointed out at some length that the actual purpose of the screen-grid valve is to enable a stable R.F. amplifier stage to be built. However, we are always learning something fresh, and this time the lesson is that **it is not only the circuit and the type of valve used that makes the R.F. stage work without oscillation.** These things are without doubt important, but there is another, equally important, about which we have as yet said nothing. **It is the way in which the R.F. stage is built.**

THE IMPORTANCE OF PROPER SHIELDING

In our previous discussion of the triode R.F. stage, and why it is not very suitable for receivers, we showed how oscillation can arise because the R.F. voltage which has been amplified by the valve feeds back from the output, or plate circuit, to the input, or grid circuit. All this is quite true, but unfortunately it is not the only way in which oscillation can be caused. In the screen-grid valve, this cause of feedback is removed, or rather reduced to such an extent that it can no longer give trouble. So, if we use a screen-grid valve, and still find that the stage oscillates, there must be a second cause, so far unaccounted for. The second cause is not far to seek, when it is remembered that the use of the screen-grid valve prevents only the feedback that takes place WITHIN the valve. In other words, if there is any feedback between those parts of the circuit external to the valve, the kind of valve used will not prevent instability from occurring. What possibilities are there, then, for external feedback? The most obvious one, when it is pointed out to us, is that R.F. energy can be transferred from one coil to another, unless special precautions are taken. It will be remembered that the only fundamental difference between alternating currents of radio frequency, as distinct from others, is the difference in frequency itself, and that the special property of radio frequency currents is that these are successful at escaping from the wires that carry them and being radiated into space. It is this very property that makes R.F. so useful, and which makes radio communication possible at all. This being the case, we must expect to find that, unless we take special steps to prevent radiation from occurring, it will always be with us, so that, in applications where radiation is a disadvantage rather than an advantage, radio frequencies require special handling. It is because of this that radio circuits are constructed so different from audio frequency or power circuits. For instance, if we attempted to carry radio frequencies over hundreds of miles of wire in the same way as power is carried at only 50 cycles per second, we would be doomed to failure, since, before it had gone very far, all the power would have been lost by radiation.

Now, in an R.F. amplifier circuit, we have two tuned circuits, one in the grid and one in the plate



View of a shielded R.F. and selector stage. The R.F. tuned circuit and valve are on the right of the partition.

circuit of the valve. Since these coils are in the open air, as it were, each of them will radiate quite strongly, and because each is only a few inches at most from the other, any energy radiated from one must be partially intercepted by the other. If this happens, it will be purely a matter of luck whether the amplifier oscillates or not, because there is an even chance that the radiation picked up from the plate coil by the grid coil will reinforce the R.F. already there, or will partially cancel it out. In the latter case, the amplifier would not be unstable, but its amplification would be far below what it ought to be, so that radiation from one coil to the other can only have ill-effects, causing, as it does, either oscillation or loss of gain.

What, then, can be done to prevent this kind of feedback and its attendant ill-effects? If some means is found of combating the radiation from the individual coils, then the cause of the trouble will have been removed at its source. This is the purpose of shielding the coils in a set by placing them in copper or aluminium cans, from which only the leads protrude. It also accounts for the fact that large, 3 in. diameter coils, though very efficient electrically, are no longer used in modern receivers. The coil, plus its shield, would occupy more space than can be afforded these days, where sets are required to be small and compact. Even large console cabinets are not used

to house the works of the set so much as to provide a large area of wooden box on which to mount the speaker. For commercial sets, several methods are used for shielding the coils from each other. One is to put the coils each in a small metal can, as described above; another is to make a number of partitions under the chassis, which is also of metal, and mount the coils between these, the metal walls of the partitions providing a certain amount of shielding between the coils. Sometimes a combination of these two methods is used.

Unfortunately, neither method of shielding lends itself very well to the type of construction that we have been using for our simple one- and two-valve sets—namely, the breadboard system. This is because the cans provided for coils that can be bought in the radio shops are never completely enclosed, but are always open on one side, or rather on the bottom. This is meant to mount on a metal chassis, so that the latter forms the sixth side of the shield can, completely enclosing the coil. It can be seen, therefore, that if we are to advance from the "beginner" stage, we must sooner or later give up the breadboard method of construction, and start building circuits on metal chassis. Initially, this will probably seem very inconvenient, since parts now have to be mounted with nuts and bolts instead of being simply screwed down, and because few of us have the necessary equipment for making proper sheet-metal chassis. But once started on this type of construction, there are very few who would voluntarily go back to breadboard lay-outs, which are actually more trouble than they are worth, especially when it comes to making sets with more than two valves.

Because of all this, the next sets that we will build will all be made on metal chassis. There are several advantages ,even for simple one-valve sets, especially when these are to work on shortwave.

The illustrations on these pages are of a simple beginners' set which was described in "Radio and Electronics" under the title of the "Radel Progressive Three." The photograph shows the way the R.F. and detector circuits are separated. Here, a deep shield partition is used between the R.F. tuned circuit and the detector one. The condenser and coil for the R.F. stage can be seen towards the front of the photograph, and the R.F. amplifier valve is also on this side of the shield. Under the chassis there is another shield partition, directly under the one on top, and this has the job of shielding the wiring of the R.F. amplifier from that of the detector. Thus it can be seen that both the coils, tuning condensers, valves, and wiring are all shielded from one another, with the result that no sort of oscillation or instability is experienced with this set. The only leads that go between the two compartments are those which carry the R.F. from the plate of the R.F. amplifier to the primary of the detector coil, and the ones which carry the filament and H.T. voltages.

Next month we will feature a shortwave one-valve set, built on a metal chassis, and specially designed for the beginner to this kind of construction. The set will have plug-in coils, and will have a further innovation in that we will use an A.C. valve for the first time. This will mean using a transformer to give 6.3 volts to operate the heater of the valve, but such a transformer is quite inexpensive, and will make available for use in future circuits a large number of the more modern valves.

PUSH-BUTTON TUNER

(Continued from page 5.)

trimmers of 120 $\mu\mu$f. capacity. Only five of the dual condensers are needed—one for each station. These provide enough tuning range for the oscillator circuit, but in the aerial circuit fixed condensers will be needed in parallel for the buttons that are to be used for low-frequency stations. These are shown as C9, C11, and C13.

The amount of added fixed capacity needed will depend on the station frequency, but the following will give some idea of the ranges covered by 100, 200, and 300 $\mu\mu$f. respectively, in conjunction with the 120 $\mu\mu$f. trimmer. For stations up to 980 kc/sec., no added capacity is needed. If 100 $\mu\mu$f. is connected in parallel with the trimmer, the circuit will tune as low as 720 kc/sec. With 200 $\mu\mu$f. in parallel, the lowest frequency reached is just under 600 kc/sec., while with 300 $\mu\mu$f. the lowest frequency in the band can be reached.

These figures refer to an aerial coil intended for a 420 $\mu\mu$f. gang condenser, and if a coil is used that is designed for a 375 $\mu\mu$f. gang condenser, there will be rather greater ranges covered by each button.

As an example, it can be stated that 2YA required 300 $\mu\mu$f. in parallel with the trimmer. Both 2YC and 3YA were tuned in with 200 $\mu\mu$f. in parallel, 2ZB used no added capacity, and similarly, 2YD.

Once the station has been found by adjusting the oscillator circuit, it is a simple matter to add capacity to the aerial trimmer until the aerial circuit peaks up on the station. This is all the alignment consists of, once the I.F. circuit has been trimmed up on 2000 kc/sec.

I.F. TRANSFORMERS

The I..F transformers used for 2 mc/sec. are made nominally for 1600 kc/sec., but will reach 2000 kc/sec. quite easily if the trimmers are screwed out a little.

CONCLUSION

There is nothing unusual or difficult in the construction of this unit, and a satisfactory lay-out can easily be made by the constructor himself. Next month we will show photographs of the tuner and amplifier built together on the one chassis, complete with power supply. As we go to press the photographs were unfortunately not ready for inclusion here.

Note.—The lower end of R10 has been shown earthed. This is an obvious error, and can be corrected by interposing an 0.1 μf. condenser in the earth lead shown from the bottom end of R10.

2-METER CONVERTER

(Continued from page 41.)

The new line is 9 in. long, not counting the ¼ in. or so that is bent at right-angles to attach to the condenser stators.

The power transformer used was a small instrument-type, made for a 6X5 rectifier, and with high-voltage secondary of 150 volts-a-side. A condenser input filter is used, and the D.C. output voltage under load was 175 volts. Little if anything is to be gained by using 250 volts H.T. supply, and this small transformer does not need a bleeder or voltage divider in order to cut down the output voltage, as the next largest kind, 250 volts-a-side, would do so under the low, 25 ma. drain of the converter.

RADIO COMPONENT USERS

(Continued from page 10.)

the product. This impresses me as a sign of the strength and confidence of the industry.

The reader of this article who lives outside Britain may say: "This is all very well, but what about me? I don't get a monthly visit from the component makers' engineers; I don't even get a catalogue." On the subject of catalogues, there is little that I can say. There is a paper shortage and a shortage of printers. Agents often forget to pass on the request for catalogues, or to send out the lists when they have them. The component manufacturers are sending out their representatives, in Europe, at any rate; most of them will welcome detailed explanations of particular requirements. After all, selling components is the way they earn a living. There is another way of getting general information. The Commercial Department of the British Embassy nearest to you will pass inquiries back to London; so will the British Export Trade Research Organization; you can even write to the Radio Industry Council, 58 Russell Square, London, W.C.1, England, if you don't know where to go for what you want.

TRADE WINDS

(Continued from page 44.)

RADIO FEDERATION NOTES

Delegates representing manufacturers and traders met at Auckland early in July as assessors in connection with the proposed North Island Radio Workers' Award. The assessors representing the manufacturers were Messrs. W. B. Billing, W. Burns, and N. Souper, of Wellington, and W. Blackwell, W. C. Lewis, and T. Spencer, of Auckland. It is understood that counter-claims formulated were to be heard in Conciliation Committee in Wellington on 26th July.

* * *

PUBLICATIONS RECEIVED

Published in the "National Electrical Review" for July is a further article on the effect of fluorescent lamps on general health. National Electric, on reliable authority, states that the modern fluorescent lamp has no harmful effect whatever.

* * *

"The Story of Electronics Park" is an article reprinted in its entirety from the October, 1948, issue of "Electronics Magazine" (McGraw-Hill), and represents a complete and accurate account of General Electric's (U.S.A.) new world centre for progress through electronics.

* * *

Other trade journals received during the month have included "Westinghouse Engineer" for May, 1949, "Enterprise," the June, 1949, journal of Cory-Wright & Salmon, Ltd., and a sales broadside from S. D. Mandeno, Ltd., on Sonophone sound system.

QUESTIONS AND ANSWERS

(Continued from page 38.)

one will not tune to 28 mc/sec., but with construction and coils as specified in the original article, this is extremely unlikely, as there was a reasonable amount of overlap on the prototype model which should allow for this.

N.Z.E.I. NEWSLETTER

JOTTINGS FROM THE DISTRICTS

Christchurch

The annual general meeting of the Christchurch Branch of the Institute was held at Canterbury University College at 7.30 p.m. on 27th June.

The election of officers for the new year resulted:

Chairman, Mr. T. R. Pollard.
Deputy-Chairman, Mr. J. B. Gregory.
Secretary, Mr. A. V. Butcher.
Treasurer, Mr. J. A. Lee.
Committee: Messrs. L. D. Hepburn, J. R. Tabley, and R. G. Tulloch.

The new secretary's address is 236 Riverlaw Terrace, St. Martins, Christchurch. He is also available at Station 3YA, Christchurch, during office hours.

It is hoped that at an early date a tentative programme for the year will be available with a list of speakers and subjects, and an endeavour is to be made to increase branch membership by special circularizing of people interested in the various subjects presented at the general meetings.

Dunedin

The annual meeting of the Dunedin branch, held in the Jubilee Hall, View Street, Dunedin, resulted in the appointment of the following officers:—

Chairman, Mr. W. L. Shiel.
Deputy-Chairman, Mr. H. F. Symonds.
Council Members: Messrs. W. L. Shiel and H. F. Symonds.
Secretary-Treasurer, Mr. W. McInnes.
Management Committee: Messrs. J. S. Coombs, E. S. Anderson, and A. R. Harris.
Social Committee: Messrs. T. R. McGregor, J. Stone, and L. W. Clarke.

Mr. J. S. Coombs, M.Sc., lecturer in physics at the University of Otago, then delivered an interesting and informative address on "Precautions to be taken in Precision Measurements with A.C. Bridges."

Wellington

Members requiring information respecting Wellington district activities should contact the branch secretary, Mr. J. McCormick, c/o Radio Corporation, Courtenay Place, Wellington.

Auckland

Regular monthly meetings are being held in the State Hydro Hall, and recent lectures have included: "Radar," by Lieut.-Commander Carey, and "Pick-up Tracking Error," by Dr. K. Kreilesheimer.

Full details of future activities are available from the branch secretary, Mr. K. Keith, 177 Queen Street, Northcote, N.4.

GENERAL NEWS

Hamilton

Mr. H. A. L. Wily, c/o Test Laboratory, Box 445, Hamilton, is interested in contacting Hamilton members and those interested in electronics with a view to furtherance of electronic activity.

* * *

Would any member knowing the whereabouts of Mr. W. G. Hooper, formerly of 35 Taylor Crescent, Waltham, Christchurch, please advise the Dominion Secretary.

* * *

The next Dominion Council meeting will be held during August, and members desirous of bringing any matter forward should notify their branch secretary accordingly.

PHILIPS EXPERIMENTER

(Continued from page 27.)

modulated, it is good practice to use an aerial coupling unit so that the load on the final can be made resistive, even if the line termination is not.

GRID BIAS ARRANGEMENTS

In the circuit of the final is shown a suggested method of connecting a relay to act as an overload protection device. In a later "Experimenter" we intend to describe complete power supplies for the whole transmitter, together with suitable sequence switching and protective devices, and we will have more to say about the overload relay at that stage. Anyone who builds up the final in the meantime, however, will be well advised to use a mixture of cathode and grid-leak bias. If the final is to be used for phone only, the bias could be made all grid-leak, in which case resistor R_2 is 6000 ohms. The bias required is –70 volts for plate-modulated telephony, and with the official grid current of 12 ma., this requires a grid resistor of 5800 ohms. There will be no harm done if a value of 6000 is used instead.

If complete grid-leak bias is to be used, then the only modification to the circuit will be to omit the relay from the cathode circuit, in which case, also, the bypass condensers will not be needed. However, even where the final is not to be keyed, it is good practice to provide some protective cathode bias. To do this, the circuit remains unchanged, except that the cathode resistor is substituted for the relay coil in the diagram. It will be noticed that both audio and R.F. bypassing have been provided across the relay and/or cathode resistor so that the final can be used for either code or phone without modification. A suggested value for a protective cathode resistor is 200 ohms, which is great enough to prevent the plate and screen currents from being excessive with no excitation applied. Under working conditions, however, this cathode resistor will supply a cathode bias of 36 volts, so that now only 34 volts of bias have to be generated in the grid-leak resistor. This will therefore have to be reduced to 2800 ohms, for which 3000 will be quite near enough. The operation of the stage will be unaffected, and the grid current of 12 ma. will still be needed.

The screen-dropping resistor, it will be noted, is set down as 15k., and this value will make the screen current and voltage correct when the plate circuit is loaded so that the plate current is 150 ma. It is a good plan to use a 20k. or 25k. adjustable resistor in this position, so that there will be a certain amount of leeway to allow for slight differences in valve characteristics. If the valve used does not draw the correct screen current of 27 ma. with the 15k. resistor, the best method of adjustment is to vary the screen resistor slightly, while keeping the plate current at 150 ma. and the grid current at 12 ma., until the screen voltage is 200. If this is done, the screen current should be very close to 27 ma. The maximum screen voltage and current are 200 volts and 30 ma. respectively, and care should be taken to see that neither of these ratings is exceeded. In a pentode transmitting valve, the screen ratings are rather more important to the life of the valve than the plate ratings, and should be respected accordingly.

ABSTRACT SERVICE

(Continued from page 22.)

Lead Sulphide Photo-conductive Cells. Practical data and characteristics of improved form of lead sulphide cell. Reference to present applications.
—Electronics (U.S.A.), May, 1949, p. 111.

How to Eliminate Auto Radio Static. Article suggesting tests to be made for successful detection of various sources of noise in car radios. Appropriate treatment described.
—Radio News (U.S.A.), May, 1949, p. 38.

Magnetic Amplifiers. Clear explanation of principles, operation, and functions.
—Wireless World (Eng.), February, 1949, p. 69.

American Microgroove Records. Characteristics of Columbia microgroove records and other pertinent technical details.
—Wireless World (Eng.), April, 1949, p. 146.

Radio Interference. Explanation of interference caused when D.C. or low-frequency circuits made or broken.
—Wireless World (Eng.), April, 1949, p. 149.

LOUDSPEAKER DIVIDING NETWORKS

(Continued from page 20.)

not come out to something quite close to that of the woofer, but, even so, the step-down ratio of the transformer will be smaller, which is an advantage in some respects.

CONCLUSION

As can be seen from this article, there are quite a number of things to be taken into account in making a dual-speaker system, but home builders should not allow themselves to be put off on that account, as any time and trouble spent in working out a suitable system will be amply repaid in the results obtained. In fact, it is not too much to say that if one is prepared to go to the trouble of building a dividing network and installing the low-frequency speaker in a bass-reflex baffle, with the high-frequency speaker or speakers mounted as close as possible to the L.F. one, it will be found extremely difficult to improve on the performance except by purchasing a complete speaker system in the £50 to £100 class, so the whole business is well worth while. It will now be realized by readers why we have stuck to a single network circuit only in this article, as there is enough to think about without having to make weighty decisions as to how complex a filter one should use, and so on. The circuit presented is perfectly adequate, and quite close to the optimum in terms of performance, and it is really more important for the budding designer to realize the important issues at stake. It is with this idea that the present article has been prepared, together with the design sheet, which enables the chokes to be wound at home to a sufficient degree of accuracy, and we hope that many of our readers will have been given the urge to try something that is the next most important step towards really high-quality reproduction, once a good, low-distortion amplifier has been built. Some would even go so far as to say that the dual speaker system is even more important, as long as the amplifier is reasonably good, so we will leave readers with that thought, and the hope of better and better fidelity from home-built equipment.

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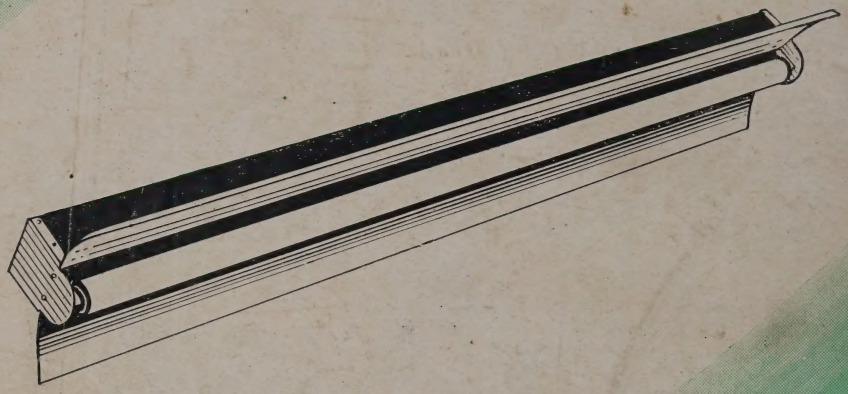

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